CITY OF CHELSEA
HAZARD MITIGATION PLAN
2022 UPDATE

DRAFT
March 17, 2022

MAPC
METROPOLITAN AREA PLANNING COUNCIL

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ACKNOWLEDGEMENTS AND CREDITS

This plan was prepared for the City of Chelsea by the Metropolitan Area Planning Council (MAPC) under the direction of the Massachusetts Emergency Management Agency (MEMA) and the Massachusetts Department of Conservation and Recreation (DCR). The plan was funded by the City of Chelsea.

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SECTION 1: EXECUTIVE SUMMARY

Hazard Mitigation planning is a proactive effort to identify actions that can be taken to reduce the dangers to life and property from natural hazard events. In the communities of the Boston region of Massachusetts, hazard mitigation planning tends to focus most on flooding, the most likely natural hazard to impact these communities. This plan also considers how our changing climate will affect natural hazards. Warming temperatures will fuel changing precipitation patterns, sea level rise, and an increasing frequency and intensity of severe storms. The Federal Disaster Mitigation Act of 2000 requires all municipalities that wish to be eligible to receive FEMA funding for hazard mitigation grants, to adopt a local multi-hazard mitigation plan and update this plan in five-year intervals.

PLANNING PROCESS

Planning for the Chelsea Hazard Mitigation Plan 2022 Update was led by the Chelsea Hazard Mitigation Team, composed of staff from a number of different City Departments. The team met on August 10 and October 21, 2021, and February 3 and March 14, 2022, and discussed where the impacts of natural hazards affect the City, the effects of climate change, goals for addressing these impacts, updates to the City's existing mitigation measures, and new or revised hazard mitigation measures that would benefit the City.

Public participation in this planning process is important for improving awareness of the potential impacts of natural hazards and to build support for the actions the City takes to mitigate them. Two advertised public meetings were held remotely via Zoom, the first on February 22, 2022, hosted by the Chelsea Planning Board, the second on March 22, 20222, also hosted by the Chelsea Planning Board. Key city stakeholders and neighboring communities were notified and invited to review the draft plan and submit comments. The draft Plan also was posted on the City's website for public review following the second public meeting. Both meetings included a description of the hazard mitigation planning process, an overview of the plan and its recommended mitigation actions, as well as directions on how the public could access the draft plan on the City website and make comments.

RISK ASSESSMENT

The Chelsea Hazard Mitigation Plan assesses the potential impacts to the City from multiple natural hazards, including flooding, high winds, winter storms, brush fire, geologic hazards, extreme temperatures, and drought. For each hazard, the plant identifies the projected impacts of a warming climate. These are shown in the map series in Appendix A. The Chelsea Local Hazard Mitigation Planning Team identified 52 Critical Facilities, including 36 from the 2017 plan and 16 additional facilities for this 2022 plan update. These are also shown on the map series and listed in Table XX , identifying which facilities are located within the mapped hazard zones.

Hazards U.S. – Multihazards (HAZUS-MH) is a standardized methodology developed by FEMA that utilizes Geographic Information Systems (GIS) to estimate physical, economic, and social impacts of disasters. The HAZUS-MH analysis for Chelsea estimates property damages from hurricanes of 100-year and 500-year frequency (approximately Categories 2 and 4) from $24.6 million to $113.9 million; see Table 20 for the hurricane Saffir-Simpson Scale defining hurricane categories. HAZUS-MH estimates property damage from earthquakes of magnitudes 5 and 7 from $580.7 million to $3.76 billion); see Table 30 for the Richter Scale defining

earthquake severity. The estimated property damage from the 1% and 0.2% chance of flooding ranges from $141.1 million to $754.4 million. An explanation of the annual chance or annual exceedance probability of floods can be found at: https://www.usgs.gov/special-topics/water-science-school/science/100-year-flood

HAZARD MITIGATION GOALS

The Chelsea Local Hazard Community Planning Team endorsed the following hazard mitigation goals at the October 21, 2021, team meeting. The team added two new goals for this 2022 plan update focusing on climate change and vulnerable populations (Goas # 10 and 11 below)

1. Prevent and reduce the loss of life, injury and property damages resulting from all major natural hazards.

2. Identify and seek funding for measures to mitigate or eliminate each known significant flood hazard area.

3. Integrate hazard mitigation planning as an integral factor in all relevant municipal departments, committees, and boards.

    - Continue to use the CIP as a tool for accomplishing mitigation projects.
    - Ensure that the Planning Department considers hazard mitigation in its review and permitting of new development.
    - Review zoning regulations to ensure that the ordinance incorporates all reasonable hazard mitigation provisions.
    - Ensure that the Building Department has the resources to continue to enforce building regulations.

4. Prevent and reduce the damage to public infrastructure resulting from all hazards.

    - Begin to assess the vulnerability of municipal buildings and infrastructure to damage from an earthquake.
    - Maintain existing mitigation infrastructure in good condition.

5. Encourage the business community, major institutions, and non-profits to work with the City to develop, review and implement the hazard mitigation plan.

6. Work with surrounding communities, state, regional and federal agencies to ensure regional cooperation and solutions for hazards affecting multiple communities. Continue to participate in the Mystic Region LEPC.

7. Ensure that future development meets federal, state and local standards for preventing and reducing the impacts of natural hazards.

8. Educate the public about natural hazards and mitigation measures that can be undertaken by property-owners. Provide information in the languages frequently spoken in Chelsea.

9. Take maximum advantage of resources from FEMA and MEMA to educate City staff and the public about hazard mitigation.

10. Consider the impacts of climate change. Incorporate climate sustainability and resilience into hazard mitigation planning and the Town's other plans and policies.

11. Ensure that the City's Hazard Mitigation efforts consider the impacts of natural hazards on vulnerable populations and address their needs for mitigation.

HAZARD MITIGATION STRATEGY

The Chelsea Local Hazard Mitigation Planning Team identified a number of mitigation measures that would serve to reduce the City's vulnerability to natural hazard events. Overall, the hazard mitigation strategy recognizes that mitigating hazards for Chelsea will be an ongoing process as our understanding of natural hazards and the steps that can be taken to mitigate their damages changes over time. Global climate change and a variety of other factors will impact the City's vulnerability in the future, and local officials will need to work together across municipal lines and with state and federal agencies in order to understand and address these changes. The Hazard Mitigation Strategy will be incorporated into the City's other related plans and policies.

PLAN REVIEW & UPDATE PROCESS

The process for updating Chelsea's Hazard Mitigation Plan is summarized in Table 1.

Table 1: Plan Review and Update Process

Section	Reviews and Updates
Section 3: Public Participation	The Local Hazard Mitigation Planning Team placed an emphasis on public participation for the update of the Hazard Mitigation Plan, discussing strategies to enhance participation opportunities at the first local committee meeting. During plan development, the plan was discussed at two public meetings hosted by the Hazard Mitigation Team and the Planning Board. The plan was also available on the City's website for public comment.
Section 4: Risk Assessment	MAPC gathered the most recently available climate, hazard and land use data and met with city staff to identify changes in local hazard areas and development trends. City staff reviewed critical infrastructure with MAPC staff in order to create an up-to-date list. The Risk Assessment integrates projected climate impacts. MAPC also used the most recently available version of HAZUS-MH and assessed the potential impacts of flooding using the latest data.
Section 5: Goals	The Hazard Mitigation Goals were reviewed and endorsed by the Chelsea Local Hazard Mitigation Planning Team. Two new goals were added for this plan update to address climate change and equity.

Section 6: Existing Mitigation Measures	The list of existing mitigation measures was updated to reflect current mitigation activities in the city.
Sections 7 and 8: Hazard Mitigation Strategy	Mitigation measures from the 2017 plan were reviewed and assessed as to whether they were completed, in progress, or deferred. The Local Hazard Mitigation Planning Team determined whether to carry forward measures into this 2022 plan update or modify or delete them. The Plan Update's hazard mitigation strategy reflects both revised mitigation measures and measures carried forward from the 2017 plan. The Hazard Mitigation Team provided cost estimates where available, time frames for implementation, and prioritized the mitigation measures based on current conditions.
Section 9: Plan Adoption & Maintenance	This section of the plan was updated with an ongoing plan implementation review and five-year update process that will assist the City in incorporating hazard mitigation issues into other City planning and regulatory review processes and better prepare the City for the next comprehensive plan update.

As indicated in Table 42, Chelsea made progress on implementing some mitigation measures identified in the 2017 Hazard Mitigation Plan. The City completed a waterfront flooding assessment, *Designing Coastal Community Infrastructure for Climate Change*, and also prepared the *Beacham/Williams Street Corridor Study in 2018*. The City adopted an update stormwater ordinance that complies with EPA's requirements for the MS4 Stormwater Permit. Several large long-term infrastructure projects were started and are partially completed, including Spruce and Blossom Streets drainage, Spruce Street CSO separation, Island End culvert, Willow Street pump station, and Eastern Avenue Green Infrastructure.

Moving forward into the next five-year plan implementation period several of the projects in progress will be completed and there will be more opportunities to incorporate hazard mitigation into the City's decision-making processes.

The City will document any actions taken within this iteration of the Hazard Mitigation Plan on challenges met and actions successfully adopted as part of the ongoing plan maintenance to be conducted by the Chelsea Hazard Mitigation Team, as described in Section 9 Plan Adoption and Maintenance.

SECTION 2: INTRODUCTION

PLANNING REQUIREMENTS UNDER THE FEDERAL DISASTER MITIGATION ACT

The Federal Disaster Mitigation Act, passed in 2000, requires that after November 1, 2004, all municipalities that wish to continue to be eligible to receive FEMA funding for hazard mitigation grants, must adopt a local multi-hazard mitigation plan and update this plan in five-year intervals. This planning requirement does not affect disaster assistance funding.

Federal hazard mitigation planning, and grant programs are administered by the Federal Emergency Management Agency (FEMA) in collaboration with the states. These programs are administered in Massachusetts by the Massachusetts Emergency Management Agency (MEMA) in partnership with the Department of Conservation and Recreation (DCR).

The City of Chelsea contracted with the Metropolitan Area Planning Council (MAPC), to assist the City in updating its third local Hazard Mitigation Plan, which was first adopted in 2007 as a multijurisdictional plan and updated as a single municipality plan in 2017.

WHAT IS A HAZARD MITIGATION PLAN?

Natural hazard mitigation planning is the process of determining how to systematically reduce or eliminate the loss of life and property damage resulting from natural hazards such as floods, earthquakes, and hurricanes. Hazard mitigation means to permanently reduce or alleviate the losses of life, injuries, and property resulting from natural hazards through long-term strategies. These long-term strategies include planning, policy changes, programs, projects, and other activities. This plan incorporates consideration of future risks due to projections for the increased frequency and severity of extreme weather fueled by a warming planet.

PREVIOUS FEDERAL/STATE DISASTERS

Since 1991, there have been 22 natural hazard events that triggered federal or state disaster declarations that included Suffolk County. These are listed in Table 2 below. The majority of these events involved flooding, while others were due to hurricanes or nor'easters, and severe winter weather.

Table 2: Presidentially Declared Disasters 1991-2018

Disaster Name	Date of Event	Declared Areas
Hurricane Bob	August 1991	Counties of Barnstable, Bristol, Dukes, Essex, Hampden, Middlesex, Plymouth, Nantucket, Norfolk, Suffolk
Severe Coastal Storm No Name Storm	October 1991	Counties of Barnstable, Bristol, Dukes, Essex, Middlesex, Plymouth, Nantucket, Norfolk, Suffolk

Disaster Name	Date of Event	Declared Areas
Blizzard	March 1993	Statewide
Blizzard	January 1996	Statewide
Severe Storms, Flood	October 1996	Counties of Essex, Middlesex, Norfolk, Plymouth, Suffolk
Heavy Rain, Flood	June 1998	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester
Severe Storms, Flood	March 2001	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester
Snowstorm	February 2003	Statewide
Snowstorm	December 2003	Barnstable, Berkshire, Bristol, Essex, Franklin, Hampden, Hampshire, Middlesex, Norfolk, Plymouth, Suffolk, Worcester
Flooding	April 2004	Essex, Middlesex, Norfolk, Suffolk, Worcester
Snow	January 2005	Statewide
Hurricane Katrina	August 2005	Statewide
Severe Storms, Flooding	October 2005	Statewide
Severe Storms, Flooding	May 2006	Statewide
Severe Storm, Inland, Coastal Flooding	April 2007	Statewide
Severe Winter Storm	December 2008	Berkshire, Bristol, Essex, Franklin, Hampden, Hampshire, Middlesex, Suffolk, Worcester
Severe Storms, Flooding	December 2008	Statewide
Severe Storms, Flooding	March/April 2010	Bristol, Essex, Middlesex, Suffolk, Norfolk, Plymouth, Worcester
Severe Winter Storm, Snowstorm	January 2011	Berkshire, Essex, Hampden, Hampshire, Middlesex, Norfolk, Suffolk
Severe Winter Storm, Snowstorm; Flooding	February, 2013	Statewide
Severe winter storm, snowstorm, flooding	April 2015	Barnstable, Bristol, Dukes, Essex, Middlesex, Nantucket, Norfolk, Plymouth, Suffolk, Worcester
Severe winter storm and Snowstorm	March 2018	Essex, Middlesex, Norfolk, Suffolk, Worcester

Source: MA Hazard Mitigation and Climate Adaptation Plan, 2018

FEMA FUNDED MITIGATION PROJECTS

The City of Chelsea has received funding from FEMA for one mitigation projects under the Hazard Mitigation Grant Program (HMGP). This project totaled $879,913.75, with $754,913.75 covered by FEMA grants and $125,000 by local funding. The project is summarized in Table 3 below..

Table 3. FEMA-Funded Mitigation Projects

Project Title	Scope of Work	Total Cost	Federal Funding	Local Funding
Crescent Ave. Flood Mitigation	Construct storm sewer tie-in to MWRA storm drain.	$879,913.75	$754,913.75	$125,000.00

(Source: database provided by MEMA)

COMMUNITY PROFILE

Located in the Boston Basin coastal plain, the City of Chelsea is bounded to the north and east by Revere, to the west by Everett, and to the south Boston (Charlestown and East Boston).

Settled in 1624, Chelsea is an old City with a rich history. The Industrial Revolution transformed the once pastoral suburb into a bustling manufacturing center. Chelsea flourished and its ethnically diverse population boomed. Undaunted by a massive fire in 1908 and again in 1973, the citizens and business people of Chelsea rebuilt their City each time with a remarkable zeal and determination. Growth resumed; prosperity returned. Hundreds of thriving businesses were proud to call Chelsea their home. Although noticeable industrial, Chelsea has many other important assets -tree-lined streets with affordable, well-kept homes, ballparks, playgrounds, excellent schools and a bustling, friendly downtown, plus three National Register Districts.

As a diverse community that contains a high level of industrial activity, Chelsea has many similarities to its neighboring cities; Revere, Everett and the East Boston portion of Boston are similarly working class residential and industrial areas.

Chelsea has four and one-half miles of waterfront made up of four bordering waterways. These are the Island End River, the Mystic River, Chelsea Creek, and Mill Creek. Three bridges provide vehicular access from Chelsea to Boston. The Tobin Bridge (Route 1) connects to Charlestown, and the Meridian Street and Chelsea Street Bridges connect to East Boston.

Most of Chelsea's major land use patterns have been influenced by its context. As a result of its proximity to Boston, Chelsea has become the site of distribution centers such as the New England Produce Market. The relationship to Logan Airport has made Chelsea an attractive location for airport-related commercial and industrial activity, including freight forwarding and employee parking. Chelsea's waterfront provides access to Boston Harbor, the majority of which is restricted to industrial and maritime uses under the state's Designated Port Area (DPA) regulations. As a result of this, a number of petroleum storage facilities and a salt pile are located on the Chelsea waterfront.

Transportation

Major highways such as Route I, Route 16 traverse the City. Transit services including commuter rail, MBTA bus lines, and a recently developed Silver Line bus rapid transit line are also available. Logan International Airport, the eighth busiest airport in the world, is just five minutes away. Area import/export operations are facilitated by a well-marked network of commercial roads that services the airport.

Water Supply and Wastewater Services

Chelsea receives its water supply and wastewater management services from the Massachusetts Water Resources Authority (MWRA) system. Existing and new development in Chelsea is serviced by the public water distribution system and the public sanitary sewer system.

Approximately 70 percent of Chelsea's sewer system is a combined system—both wastewater and stormwater are carried through the same conduits. During periods of dry weather Chelsea's wastewater is conveyed to the MWRA and onto Deer Island for treatment. During periods of heavy rain some of the combined wastewater and stormwater is discharged untreated via four Combined Sewer Overflows (CSOs). This action prevents backups of flows into area homes and 24 Community Setting businesses. The four CSOs are as follows7: (1) CHE002 Located on Broadway and discharges to Boston Inner Harbor, (2) CHE003 Located on Winnisimmet Street and discharges to Chelsea River, (3) CHE004 Located on Pearl Street and discharges to Chelsea River, and (4) CHE008 Located on Eastern Avenue and discharges to Chelsea River. Separation of combined sewers is something the City is in the process of accomplishing. This will both increase service efficiency and decrease environmental contamination via untreated CSO discharges. Additionally, the upgrade of water mains is an ongoing concern in the City.

Governance

Since 1995, Chelsea city government has operated under a Manager/Council form of government. A strong city manager maintains all hiring and firing authority and is responsible for the day-to-day operations of a twenty-first century municipality. The 11-member City Council that selects a City Manager is also responsible for budget adoption, general policy development and approval and oversight of the municipal administration. The two-year Council is comprised of three members elected at-large and eight elected in individual districts. The City maintains a website at http://www.chelseama.gov

Population and Demographics

The City has a population of 40,787 (2020 US Census) in a land area of 2.2 square miles. The population density is approximately 18,624 people per square mile, one of the densest cities in the state. Chelsea's population increased by 5,600, or 16%, in just ten years from 2010 to 2020. Demographic characteristics are shown in Table 4 below.

Chelsea has significant Environmental Justice (EJ) populations throughout the City. There are 27 EJ census block groups within the City, as identified by MassGIS. These EJ populations are defined as minority or foreign-born populations exceeding 25 percent of the total block group or a household earning 65 percent or less of the statewide median household income.

Table 4. Chelsea Demographic Characteristics

Population (2020) 40,787

- 8.7% are under the age 5
- 26.0% are under age 18
- 9.5% are over age 65
- 45.5% are foreign-born
- 69.8 % speak a language other than English at home
- 39.2% speak English less than very well
- 18.2% persons in poverty
- 12.9% have a disability
- 50.4% of those over age 65 have a disability
- 30.2% have no vehicle

Number of Housing Units (2020) 13,907

- 74.1% are renter-occupied housing units
- 55.7% of housing units were built prior to 1940
- 68.3% of housing units were built prior to 1970

Source: U.S. Census, 2020; American Community Survey 2019

The primary ethnic group in Chelsea is Hispanic and therefore the language most frequently spoken aside from English is Spanish. Asian populations are also significant, which can encompass a variety of languages. Of the 27 census block groups, only five fall below the 75% threshold for English proficiency. The 27 EJ areas are shown on the map in Figure 1.

Planning Context

The City of Chelsea has several unique characteristics to keep in mind while planning for natural hazards:

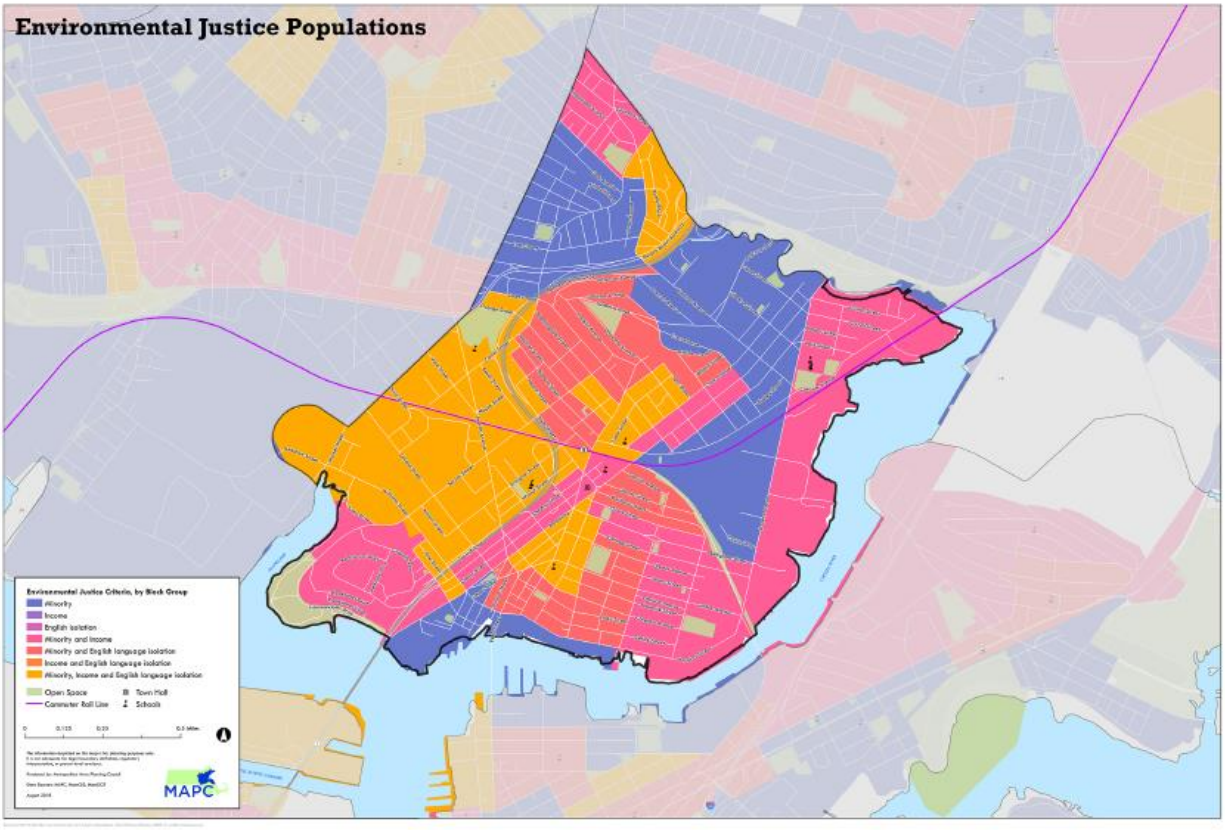
- Chelsea has been proactive in addressing the impact of climate change on natural hazards. The community is certified by the state as a Municipal Vulnerability Preparedness com unity, and has prepared a plan, *Designing Coastal Community Infrastructure for Climate Change*.
- Chelsea is an active member of the Metro Mayors Climate Task Force, a group of 15 urban core communities that collaborate on climate resilience initiatives locally and regionally.
- Chelsea, Everett, and Revere participates in the North Suffolk Office of Resilience and Sustainability.

- Chelsea is located in the Mystic River watershed. The City collaborates with cities of Boston, Everett, Somerville, Revere and Winthrop in the Resilient Mystic Collaborative, which prepared the Lower Mystic Regional Climate Assessment.

- The City has been pro-active in reaching out to these communities, and there are several community-based organizations serving the City's Environmental Justice community, including GreenRoots and La Colaborativa (The Chelsea Collaborative).

- Records of flood damages from the major storms of 2010 show that limited flood damage occurred throughout the city, with 11 disaster flood claims filed with FEMA, 91% of which were located outside the FEMA 1% chance flood zone.

Figure 1 Chelsea Environmental Justice Populations



Source: Chelsea Open Space and Recreation Plan 2017-2024

SECTION 3: PLANNING PROCESS & PUBLIC PARTICIPATION

MAPC employs a six-step planning process based on FEMA's hazard mitigation planning guidance focusing on local needs and priorities but maintaining a regional perspective matched to the scale and nature of natural hazard events and regional climate change. Public participation is a central component of this process, providing critical information about the local occurrence of hazards while also serving as a means to build a base of support for hazard mitigation activities. MAPC supports participation by the general public and other plan stakeholders through two public meetings, posting of the plan to the City's website, and invitations sent to neighboring communities, city boards and commissions, and other local or regional entities to review the plan and provide comment.

PLANNING PROCESS SUMMARY

The six-step planning process outlined below is based on the guidance provided by FEMA's Local Multi-Hazard Mitigation Planning Guidance. Public participation is a central element of this process, which attempts to focus on local problem areas and identify needed mitigation measures based on where gaps occur in the existing mitigation efforts of the municipality. In plan updates, the process described below allows staff to bring the most recent hazard information into the plan, including new hazard occurrence data, changes to a municipality's existing mitigation measures, and progress made on actions identified in previous plans.

Figure 2: Six-Step Planning Process

1. **Map the Hazards** – MAPC relies on data from a number of different federal, state, and local sources in order to map the areas with the potential to experience natural hazards. This mapping represents a multi-hazard assessment of the municipality and is used as a set

of base maps for the remainder of the planning process. A particularly important source of information is the knowledge drawn from local municipal staff on where natural hazard impacts have occurred. These maps can be found in Appendix A.

2. **Assess the Risks & Potential Damages** – Working with City staff, critical facilities, infrastructure, vulnerable populations, and other features are mapped and contrasted with the hazard data to identify those that might represent particular vulnerabilities to these hazards. Land use data and development trends are also incorporated into this analysis. In addition, MAPC develops estimates of the potential impacts of certain hazard events on the community. MAPC drew on the following resources to complete the plan:

    - City of Chelsea, *Designing Coastal Community Infrastructure for Climate Change*, 2017
    - City of Chelsea, *Beacham/Williams Street Corridor Study*, 2018
    - City of Chelsea, *Community Resilience Building Summary of Findings*, 2018
    - City of Chelsea, Code of Ordinances, Chapter 30, Article V, Sewers and Storm Drains
    - City of Chelsea, *Open Space and Recreation Plan*, 2017
    - City of Chelsea, *Proposed Chelsea Creek Municipal Harbor Plan,* 2021
    - City of Chelsea, *Willow Street Area Sewer Separation and Flood Mitigation Project*
    - City of Chelsea, Zoning Ordinance
    - Blue Hill Observatory
    - FEMA, Flood Insurance Rate Maps for Suffolk County, MA, 2016
    - FEMA, Hazards U.S. Multi-Hazard (HAZUS-MH), 2021
    - FEMA, Local Mitigation Plan Review Guide, October 2011
    - Fourth National Climate Assessment, 2018
    - Massachusetts Drought Management Plan, 2019
    - Massachusetts Office of Dam Safety, Inventory of Massachusetts Dams 2018
    - Massachusetts State Hazard Mitigation Plan, 2013
    - Massachusetts State Hazard Mitigation and Climate Adaptation Plan, 2018
    - National Weather Service
    - Nevada Seismological Library
    - New England Seismic Network, Boston College Weston Observatory
    - NOAA National Centers for Environmental Information
    - Northeast Climate Adaptation Science Center
    - Northeast States Emergency Consortium
    - Resilient Mystic Collaborative, Lower Mystic Regional Climate Assessment, 2021
    - Tornado History Project
    - Urban Land Institute, Living with Heat, Chelsea and Everett
    - US Census, 2020 and American Community Survey 2019, 5-Year Estimates
    - USGS, National Water Information System

3. **Review Existing Mitigation** – Municipalities in the Boston Metropolitan Region have an active history in hazard mitigation as most have adopted flood plain zoning districts, wetlands protection programs, and other measures as well as enforcing the State building code, which has strong provisions related to hazard resistant building requirements. Many communities have started adopting regulations designed to promote climate resilience. All current municipal mitigation measures must be documented.

4. **Develop Mitigation Strategies** – MAPC works with the municipal staff to identify new mitigation measures, utilizing information gathered from the hazard identification, vulnerability assessments, and the community's existing mitigation efforts to determine where additional work is necessary to reduce damages from hazard events. Additional information on the development of hazard mitigation strategies can be found in Section 7.

5. **Plan Approval & Adoption** – Once a final draft of the plan is complete it is sent to MEMA for the state level review and, following that, to FEMA for approval. Typically, once FEMA has approved the plan the agency issues a conditional approval (Approval Pending Adoption), with the condition being adoption of the plan by the municipality. More information on plan adoption can be found in Section 9 and documentation of plan adoption can be found in Appendix D.

6. **Implement & Update the Plan** – Implementation is the final and most important part of any planning process. Hazard Mitigation Plans must also be updated on a five-year basis making preparation for the next plan update an important on-going activity. Section 9 includes more detailed information on plan implementation.

2017 PLAN IMPLEMENTATION & MAINTENANCE

The 2017 City of Chelsea Hazard Mitigation Plan contained a risk assessment of identified hazards for the city and mitigation measures to address the risk and vulnerability from these hazards. Since approval of the plan by FEMA and local adoption progress has been made on implementation of several mitigation measures. The City completed a waterfront flooding assessment, *Designing Coastal Community Infrastructure for Climate Change*, and also prepared the *Beacham/Williams Street Corridor Study* in 2018. The City adopted an updated stormwater ordinance that complies with EPA's requirements for the MS4 Stormwater Permit. Several large long-term infrastructure projects were started and are partially completed, including Spruce and Blossom Streets drainage, Spruce Street CSO separation, Island End culvert, Willow Street pump station, and Eastern Avenue Green Infrastructure.

In addition, the City completed a Municipal Vulnerability Preparedness project and has been certified as an MVP Community by the state. Chelsea also collaborates with surrounding communities in the Metro Mayors Climate Task Force, the Resilient Mystic Collaborative, and the North Suffolk Office of Resilience and Sustainability.

THE LOCAL HAZARD COMMUNITY PLANNING TEAM

MAPC worked with the local community representatives to organize a Local Hazard Mitigation Planning Team for Chelsea. MAPC briefed the local representatives as to the desired composition of that team as well as the need for public participation in the local planning process.

The Local Hazard Mitigation Planning Team is central to the planning process as it is the primary body tasked with developing a mitigation strategy for the community. The local team was tasked with working with MAPC to set plan goals, provide information on the hazards that impact the city, existing mitigation measures, and helping to develop new mitigation measures for this plan update. The Local Hazard Mitigation Planning Team membership is listed below.

Tom Ambrosino, City Manager
Leonard Albanese, Chief, Fire Department
Flor Amaya, Director of Public Health
Ben Cares, Senior Planner, Department of Housing and Community Development
John DePreist, Director/Conservation Agent, Dept. of Permitting & Land Use Planning
Ibrahim Lopez Hernandez, Sustainability Manager, Housing and Community Development
Lou Mammolette, P.E., City Engineer; Deputy Commissioner Dept. of Public Work
Darya Mattes , Resilience Manager, North Suffolk Office of Resilience and Sustainability
Maria Belen Power, Associate Executive Director, GreenRoots
Steve Staffier, Director, Emergency Management
Alexander Train, Director, Housing and Community Development Dept.
Gladys Vega, Director, Chelsea Collaborative
Rebecca Wright, Assistant City Engineer, Department of Public Works

The Chelsea Planning Board and Conservation Commission are the primary entities responsible for regulating development in city. Feedback was assured through the participation of the Director of Dept. of Permitting & Land Use Planning, who also serves as the City's Conservation Agent. The Planning Board hosted the two public meetings on the plan. In addition, MAPC, the State-designated regional planning authority for the Boston metropolitan region, works with all agencies that that regulate development in the region, including the listed municipal entities and state agencies, such as the Department of Transportation.

The Local Hazard Mitigation Planning Team met on the following dates: August 10 and October 21, 2021, and February 3 and March 14, 2022. The purpose of the meetings was to introduce the Hazard Mitigation planning program, consider climate impacts, review, and update hazard mitigation goals, and to gather information on local hazard mitigation issues and sites or areas related to these. Later meetings focused on verifying information gathered by MAPC staff and discussion of existing mitigation practices, the status of mitigation measures identified in the 2017 Hazard Mitigation Plan, and potential new or revised mitigation measures. The agendas for these meetings are included in Appendix B.

PUBLIC MEETINGS

Public participation in the hazard mitigation planning process is important, both for plan development and for later implementation of the plan. Residents, business owners, and other community members are an excellent source for information on the historic and potential impacts of natural hazard events and particular vulnerabilities the community may face from these hazards. Their participation in this planning process also builds understanding of the concept of hazard mitigation and climate impacts, potentially creating support for mitigation actions taken in the future to implement the plan. To gather this information and educate residents on hazard mitigation, the city hosted two public meetings, one during the planning process and one after a complete draft plan was available for review.

The public had an opportunity to provide input to the Chelsea hazard mitigation planning process during a public meeting held on February 22, 2022, hosted by the Chelsea Planning Board. The draft plan update was presented at a public meeting hosted by the Planning Board on March 22, 2022. Both meetings were publicized in accordance with the Massachusetts Public Meeting Law. Meeting notices were also circulated in both English and Spanish. The meeting agendas and public meeting notices are found in Appendix C.

LOCAL STAKEHOLDER INVOLVEMENT

The local Hazard Mitigation Planning Team reached out to local stakeholders that might have an interest in the Hazard Mitigation Plan including neighboring communities, agencies, businesses, nonprofits, and other interested parties. Notice was sent to the following organizations and neighboring municipalities inviting them to review the Hazard Mitigation Plan and submit comments to the city. In addition, meetings were advertised in the local press, on the city website, and through City social media platforms. The following organizations, departments, and neighboring communities received invitations to attend the public meeting:

- City of Boston
- City of Everett
- City of Revere
- La Colaborativa/The Chelsea Collaborative
- GreenRoots
- CAPIC
- The Neighborhood Developers
- Beth Israel/Leahy Health Community Initiatives
- Chelsea Community Connections
- MGH/Partners Health Care
- Chelsea Housing Trust Fund board
- Chelsea Housing Authority

See Appendix C for public meeting notices and agendas. The draft Chelsea Hazard Mitigation Plan 2022 Update was posted online for the second public meeting. Members of the public could access the draft document and submit comments or questions to the city.

CONTINUING PUBLIC PARTICIPATION

Following the adoption of the plan update, the Hazard Mitigation Team will continue to provide residents, businesses, and other stakeholders the opportunity to learn about the hazard mitigation planning process and to contribute information that will update the city's understanding of local hazards. As updates and a review of the plan are conducted by the Hazard Mitigation Team, these will be placed on the City's web site, and any meetings of the Team will be publicly noticed in accordance with city and state open meeting laws.

PLANNING TIMELINE, 2021-2022

August 10, 2021	1st Meeting of the Chelsea Local Hazard Mitigation Team
October 21, 2021	2nd Meeting of the Chelsea Local Hazard Mitigation Team
February 3, 2022	3rd Meeting of the Chelsea Local Hazard Mitigation Team
February 22, 2022	First Public Meeting hosted by the Chelsea Planning Board
March 14, 2022	4th Meeting of the Chelsea Local Hazard Mitigation Team
March 22, 2022	Second Public Meeting hosted by the Chelsea Planning Board
TBD	Draft Plan Update submitted to MEMA
TBD	Draft Plan Update submitted to FEMA
TBD	Notice of Approvable Pending Adoption sent by FEMA
TBD	Plan Adopted by the City of Chelsea
TBD	FEMA final approval of the plan for 5 years

IMPLEMENTATION AND PLAN UPDATE TIMELINE, 2022-2027

2024	Conduct Mid-Term Plan Survey on Progress
2025	Seek FEMA grant to prepare next plan update
2026	Begin process to update the plan
2027	Submit Draft 2027 Plan Update to MEMA and FEMA
2027	FEMA approval of 2027 Plan Update

SECTION 4: RISK ASSESSMENT

The risk assessment analyzes the potential natural hazards that could occur within the City of Chelsea as well as the relationship between those hazards and current land uses, potential future development, and critical infrastructure. This section also includes a vulnerability assessment that estimates the potential damages that could result from certain large-scale natural hazard events. In order to update Chelsea's risk assessment, MAPC gathered the most recently available hazard and land use data and met with City staff to identify changes in local hazard areas and development trends. MAPC also used FEMA's damage estimation software, HAZUS-MH.

With the adoption of the State Hazard Mitigation and Climate Adaptation Plan 2018 (SHMCAP), Massachusetts became the first state to integrate climate projections into a state hazard mitigation plan. Following the state model, the projected impacts of our warming climate on natural hazards are integrated throughout the risk assessment for Chelsea. Key impacts include rising temperatures, which in turn affect precipitation patterns, sea level, and extreme weather.

> *"Global climate is changing rapidly compared to the pace of natural variations in climate that have occurred throughout Earth's history. Global average temperature has increased by about 1.8°F from 1901 to 2016, and observational evidence does not support any credible natural explanations for this amount of warming; instead, the evidence consistently points to human activities, especially emissions of greenhouse or heat-trapping gases, as the dominant cause."*
> Fourth National Climate Assessment, 2018 (Chapter 2-1)

CLIMATE CHANGE OBSERVATIONS AND PROJECTIONS

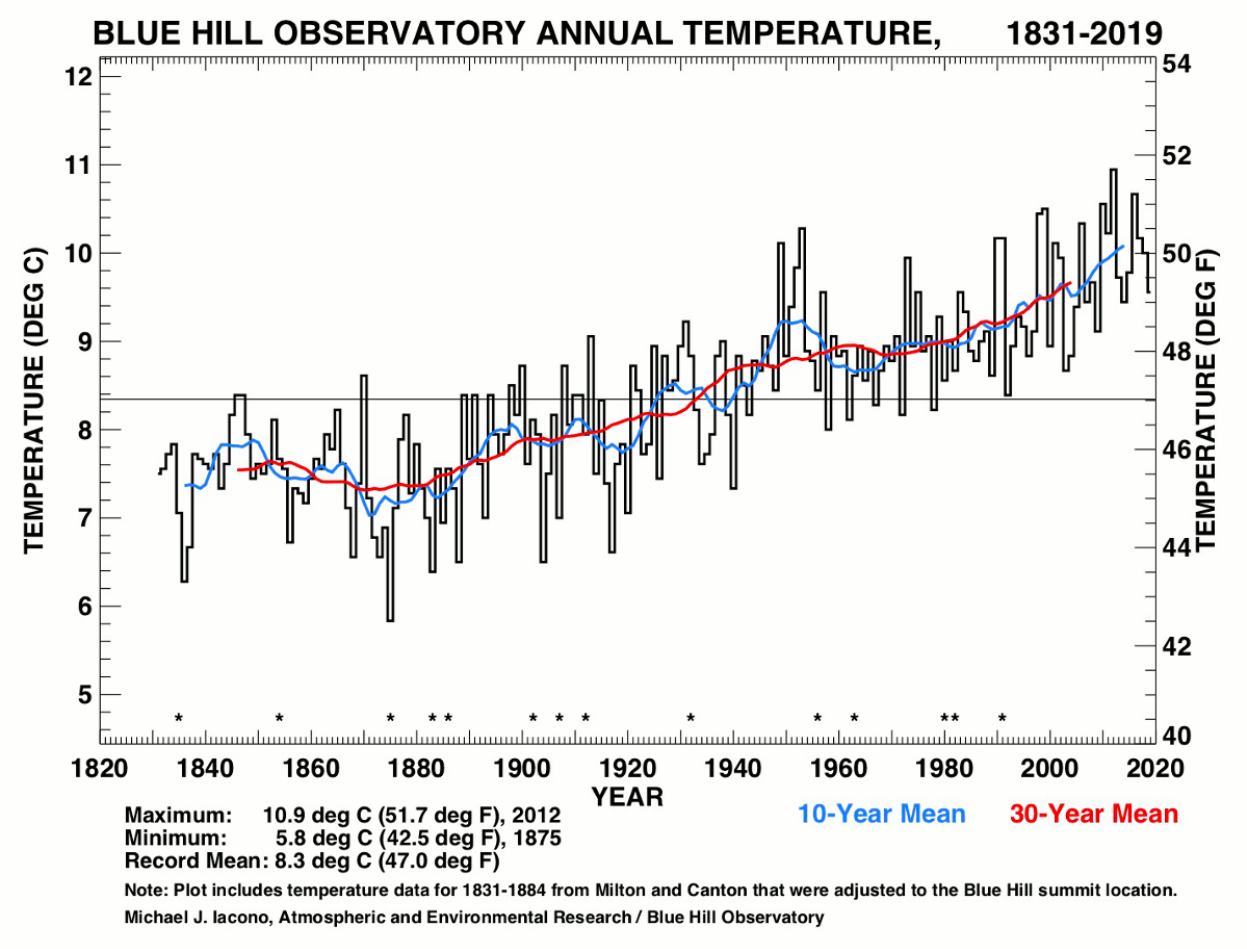
Climate change observations come from a variety of data sources that have measured and recorded changes in recent decades and centuries. Climate change projections, however, predict future climate impacts and, by their nature, cannot be observed or measured. As a result of the inherent uncertainty in predicting future conditions, climate projections are generally expressed as a range of possible impacts.

Temperature

Our climate has always been regulated by gases, including carbon dioxide, methane, and nitrous oxide, which blanket the earth. These gases trap heat that would otherwise be reflected out to space; without them our planet would be too cold to support life. We refer to these gases as "greenhouse gases" (GHGs) for their heat trapping capacity. The combustion of fossil fuels, our primary energy source in the age of industrialization, releases GHGs into the atmosphere. In the past century, human activity associated with industrialization has contributed to a growing concentration of GHGs in our atmosphere.

Records from the Blue Hill Observatory in Milton, MA show that average temperatures (30-year mean) have risen approximately 3 degrees (F) in the almost 200 years since record keeping began in 1831 (Figure 3).

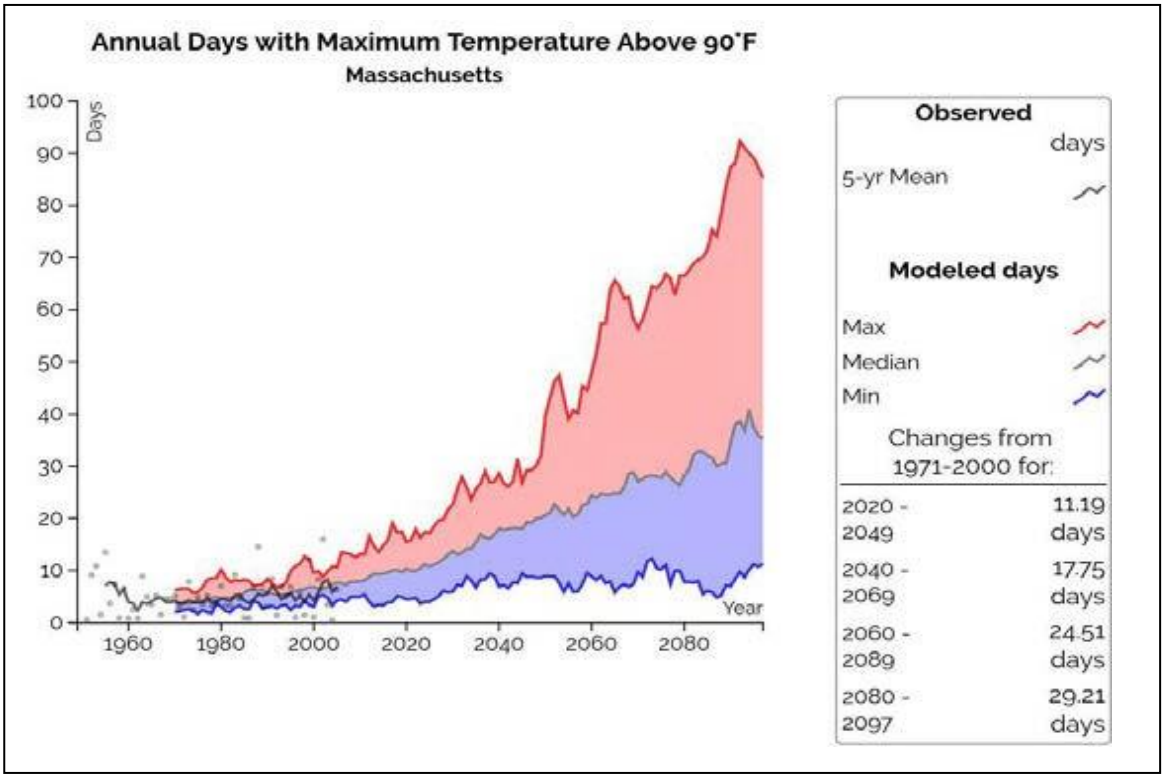
Figure 3: Observed Increase in Temperature



Source: Blue Hills Observatory

Climate projections include an increase in average temperature and in the number of extreme heat days. Extreme cold days are projected to decrease in number. The Northeast Climate Adaptation Science Center (NECASC) projects average temperatures in Massachusetts will increase by 5 degrees F by mid-century and nearly 7 degrees F by the end of the century. Figure 4 shows the NECASC range of projections for increases in the number of days over 90 degrees annually.

Figure 4: Projected Increase in Annual Days Over 90 Degrees F



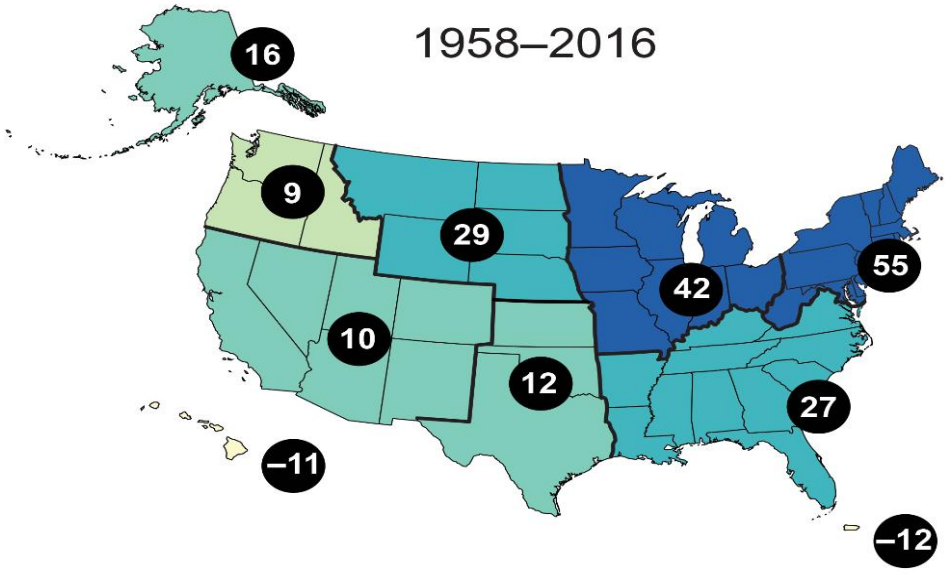
Source: Northeast Climate Adaptation Science Center

Precipitation Patterns

Annual precipitation in Massachusetts has increased by approximately 10% in the fifty-year period from 1960 to 2010 (MA Climate Adaptation Report, 2011). Moreover, there has been a significant increase in the frequency and intensity of large rain events. For the Northeast US, according to the Fourth National Climate Assessment 2018, in the past sixty years there has been a 55% increase in the amount of annual precipitation that falls in the top 1% of storm events (Figure 5). Changes in precipitation are fueled by warming temperatures which increase evaporation and, therefore, the amount of water vapor in the air.

Total annual precipitation in Massachusetts is projected to increase by 1 to 6 inches by mid-century, and by 1.2 to 7.3 inches by the end of this century (SHMCAP p. 2-22). The Fourth National Climate Assessment predicts that the pattern of increasing frequency and intensity of extreme rain events will continue. By 2070 to 2099, (relative to 1986 to 2015) they project a 30-40% increase in total annual precipitation falling in the heaviest 1% of rain events (Figure 6).

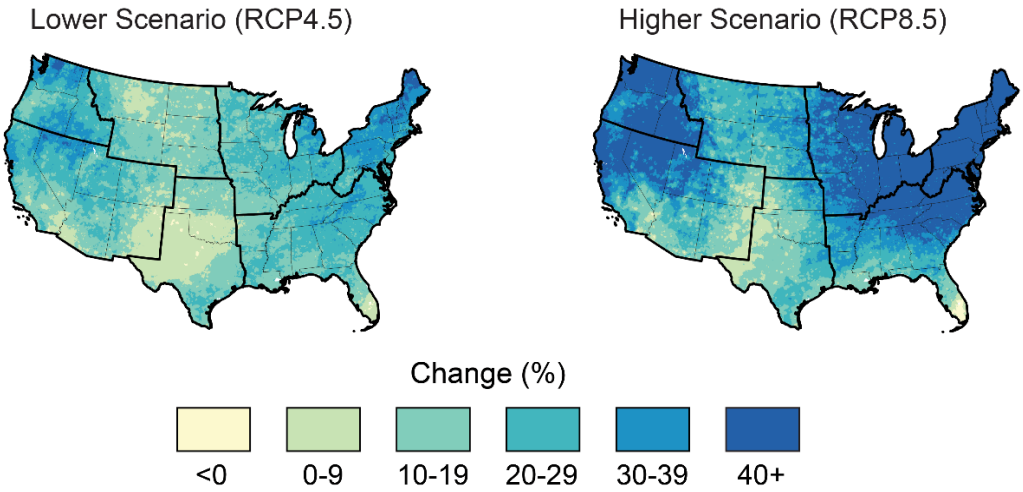
Figure 5: Observed Change in Total Annual Precipitation Falling in the Heaviest 1% of Events



Source: Fourth National Climate Assessment, 2018
Numbers circled in black indicate % change.

Despite overall increasing precipitation, more frequent and significant summer droughts are also a projected consequence of climate change. This is due to projections that precipitation will increase in winter and spring and decrease slightly in the summer and, a result of earlier snow melt, and higher temperatures that will reduce soil moisture.

Figure 6: Projected Change in Total Annual Precipitation Falling in the Heaviest of 1% of Events for 2070-2099

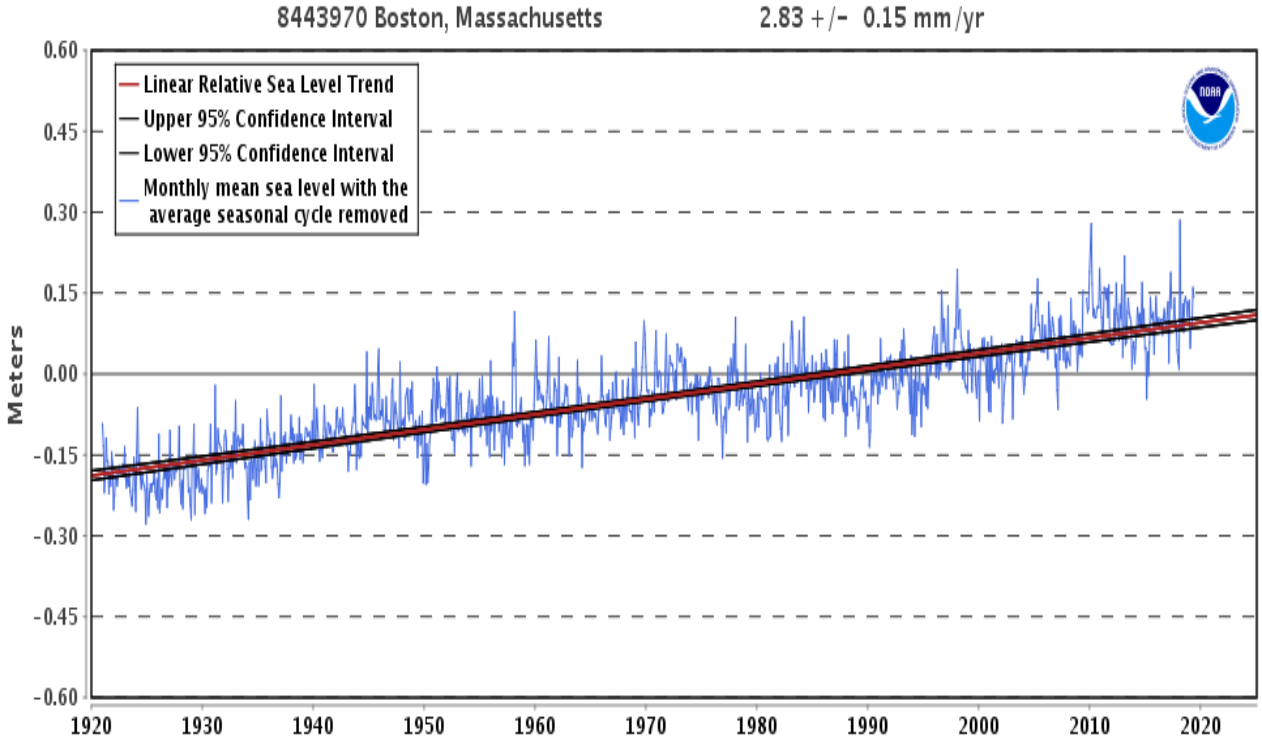


Source: Fourth National Climate Assessment, 2018

Sea Level Rise

Records from the Boston Tide Station show nearly one foot of sea level rise in the past century (Figure 7). Warming temperatures contribute to sea level rise in three ways. First, warm water expands to take up more space. Second, rising temperatures are melting land-based ice which enters the oceans as melt water. A third, quite minor, contributor to sea level rise in New England is not related to climate change. New England is still experiencing a small amount of land subsidence (drop in elevation) in response to the last glacial period.

Figure 7: Observed Increase in Sea Level Rise



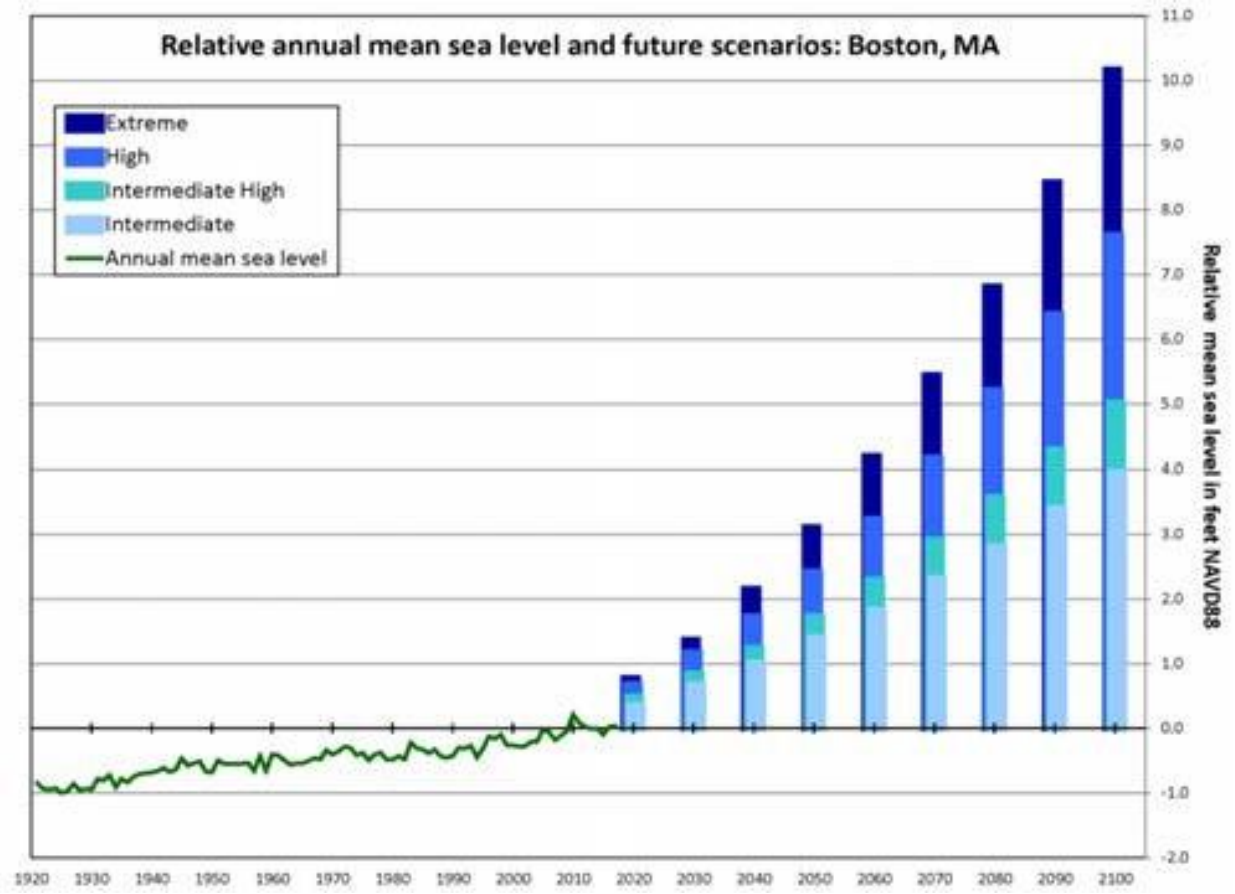
Source: NOAA

Projections of sea level rise through 2100 vary significantly depending on future greenhouse gas emissions and melting of land-based glaciers. Currently sea level is rising at an increasing rate. Figure 8 shows the recent rate of sea level rise, and a range of sea level rise scenarios. Projections for 2100 range from 4 feet to 10 feet. With ten feet representing the most extreme scenario. For 2050, the projections range approximately 1.5 to 3 feet.

Following the outline of the Massachusetts State Hazard Mitigation and Climate Adaptation Plan (SHMCAP), this local hazard mitigation plan organizes consideration of natural hazards based on their relationship to projected climate changes. Table 5 below, from the SHMCAP, summarizes the natural hazards reviewed in this plan, climate interactions, and expected impacts.

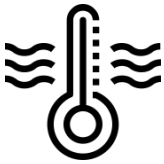
Figure 8: Recent and Projected Increase in Sea Level Rise

1



Source: SHMCAP

Table 5: Climate Change and Natural Hazards

Primary Climate Change Interaction	Natural Hazard	Other Climate Change Interactions	Representative Climate Change Impacts
 **Changes in Precipitation**	Inland Flooding	Extreme Weather	Flash flooding, urban flooding, drainage system impacts (natural and human-made), lack of groundwater recharge, impacts to drinking water supply, public health impacts from mold and worsened indoor air quality, vector-borne diseases from stagnant water, increased potential for loss of life, episodic drought, changes in snow-rain ratios, changes in extent and duration of snow cover, degradation of stream channels and wetland
	Drought	Rising Temperatures, Extreme Weather	
	Landslide	Rising Temperatures, Extreme Weather	
 **Sea Level Rise**	Coastal Flooding	Extreme Weather	Increase in tidal and coastal floods, storm surge, coastal erosion, marsh migration, inundation of coastal and marine ecosystems, loss of wetlands
	Coastal Erosion	Extreme Precipitation	
	Tsunami	Rising Temperatures	
 **Rising Temperatures**	Average/Extreme Temperatures	N/A	Shifting in seasons (longer summer, early spring, including earlier timing of spring peak flow), increase in length of growing season, increase of invasive species, increase in vector-borne illnesses (West Nile, Zika, EEE), ecosystem stress, energy brownouts from higher energy demands, more intense heat waves, public health impacts from high heat exposure and poor outdoor air quality, increased potential for loss of life, drying of streams and wetlands, eutrophication of lakes and ponds
	Wildfires	Changes in Precipitation	
	Invasive Species	Changes in Precipitation, Extreme Weather	
 **Extreme Weather**	Hurricanes/Tropical Storms	Rising Temperatures, Changes in Precipitation	Increase in frequency and intensity of extreme weather events, resulting in greater damage to natural resources, property, and infrastructure, as well as increased potential for loss of life
	Severe Winter Storm / Nor'easter		
	Tornadoes		
	Other Severe Weather (Strong Wind & Precipitation)		
Non-Climate-Influenced Hazards	Earthquake	Not Applicable	There is no established correlation between climate change and this hazard

OVERVIEW OF HAZARDS AND IMPACTS

This section analyzes the potential natural hazards that could occur within the City of Chelsea as well as the relationship between those hazards and current land uses, potential future development, and critical infrastructure.

In order to update Chelsea's risk assessment, MAPC gathered the most recently available hazard and land use data and met with the local Hazard Mitigation Team to identify changes in local hazard areas and development trends. City staff reviewed critical infrastructure in order to create an up-to-date inventory and map. MAPC also used the most recently available version of HAZUS-MH (described below) to estimate potential impacts of flooding using the latest data.

Table 6 summarizes the frequency and severity of hazard risks for Massachusetts and Chelsea. The Massachusetts assessment is based on the State Hazard Mitigation Plan. The statewide assessment was modified to reflect local conditions in Chelsea using the definitions for hazard frequency and severity listed below.

Table 6: Hazards Risk Summary

Hazard	Frequency		Severity	
	Massachusetts	**Chelsea**	**Massachusetts**	**Chelsea**
Flooding	High	High	Serious	Serious
Coastal Hazards	High	High	Serious	Serious
Extreme Temperatures	Medium	High	Minor	Serious
Nor'easters	High	High	Serious	Serious
Winter storms/blizzards	High	High	Minor	Minor
Thunderstorms	High	High	Minor	Minor
Hurricanes/Tropical Storms	Medium	Medium	Serious	Serious
Ice storms	Medium	Low	Minor	Minor
Drought	Low	Medium	Minor	Minor
Earthquakes	Very Low	Very Low	Extensive	Extensive
Tornadoes	Medium	Low	Serious	Serious
Dam failures	Very Low	N/A	Serious	N/A
Brush fires	Medium	Very Low	Minor	Minor
Landslides	Low	Low	Minor	Minor

Source: Massachusetts State Hazard Mitigation Plan, modified to reflect conditions for Chelsea

Frequency Categorization
Very low: events that occur less frequently than once in 100 years (Less than 1% per year)
Low: events that occur from once in 50 years to once in 100 years (1% to 2% per year)
Medium: events that occur from once in 5 years to once in 50 years (2% to 20% per year)
High: events that occur more frequently than once in 5 years (Greater than 20% per year)

Severity Categorization
Minor: Limited and scattered property damage; limited damage to public infrastructure and essential services not interrupted; limited injuries or fatalities.
Serious: Scattered major property damage; some minor infrastructure damage; essential services are briefly interrupted; some injuries and/or fatalities.
Extensive: Widespread major property damage; major public infrastructure damage (up to several days for repairs); essential services are interrupted from several hours to several days; many injuries and/or fatalities.
Catastrophic: Property and public infrastructure destroyed; essential services stopped; numerous injuries and fatalities

CHANGING PRECIPITATION PATTERNS

INLAND FLOODING

Inland flooding is generally caused by hurricanes, nor'easters, severe rainstorms, and thunderstorms. Nor'easters can occur at any time of the year, but they are most common in winter. Hurricanes are most common in the summer and early fall. Large rainstorms can occur year-round. Climate change has the potential to exacerbate these issues over time due to increasing extreme rainfall events. Increase in average annual rainfall may also lead to more incidents of basement flooding caused by high seasonal groundwater levels.

Flooding was the most prevalent serious natural hazard identified by local officials in Chelsea. Inland flooding can be associated with overflowing rivers and streams, but more commonly in Chelsea flooding is related to stormwater associated with impervious surfaces and urban stormwater infrastructure. Chelsea is subject to two kinds of inland flooding: inland/riverine flooding where the rate of precipitation and/or amount of stormwater runoff overwhelms the capacity of natural or structured drainage systems, and urban flooding in which precipitation causes the water table to rise and leads to flooding of low-lying areas such as streets and basements. These types of flooding are often combined as storm events lead to large amounts of draining stormwater, which can be blocked by elements of the built environment and can be backed up when drainage locations (ponds, streams, etc.) are at or above capacity. It should be noted that Chelsea is also subject to coastal flooding; see the section below "Coastal Flooding/Sea Level Rise."

Chelsea is entirely within the Mystic River watershed but is further divided into two sub-basins. The eastern half of Chelsea drains to the Chelsea Creek Sub-basin, with the western half of the City draining to the Island End River Sub-basin. Both of these waterways have the potential to flood

sections of the City. In some areas, years of shoreline modifications, land reclamation, stream piping, and development have severely altered the natural flow of water in Chelsea. Stormwater drainage from developed areas occurs primarily through the manmade system of storm drains.

Previous Occurrences and Extent of Flooding

There have been a number of major floods that have affected the Metro Boston region over the last fifty years. Significant historic flood events in Chelsea have included:

- March 1968
- The blizzard of 1978
- January 1979
- April 1987
- October 1991 ("The Perfect Storm")
- October 1996
- June 1998
- March 2001
- April 2004
- May 2006
- April 2007
- March 2010

The best available local data on the previous occurrences of flooding are from the NOAA National Centers for Environmental Information, which are provided by county. Chelsea is part of Suffolk County, for which historic flood events from 2010 through 2021 were compiled and are summarized in Table 7. Suffolk County experienced 24 flood events from 2010 through 2021. No deaths or injuries were reported, and the total reported property damage was $10.9 million dollars. Nearly all of the damage is attributed to the major storm events of March 2010, described below.
‘

Table 7: Suffolk County Flood Events, 2010 through 2021

Date	Deaths	Injuries	Property Damage
3/14/2010	0	0	$10,700,000
8/25/2010	0	0	0
10/29/2012	0	0	$15,000
6/7/2013	0	0	0
9/1/2013	0	0	$5,000
10/23/2014	0	0	$30,000
7/23/2016			0
7/12/2017			0
7/18/2017			0
8/2/2017			0
9/14/2017			$25,000
9/30/2017			$90,000
10/30/2017			0
5/15/2018			0
6/25/2018			0
8/12/2018			$10,000

9/25/2018	0	0	$3,000
11/3/2018	0	0	0
6/29/2019	0	0	$20,00
7/06/2019	0	0	0
7/31/2019	0	0	$4,000
8/7/2019	0	0	0
6/28/2020	0	0	0
7/9/2021	0	0	0
TOTAL	**0**	**0**	**$10,932,000**

Source: NOAA, National Centers for Environmental Information

The vulnerability analysis conducted by MAPC using FEMA's HAZUS-US model estimates a range of damages from flooding in Chelsea from $141.1 million for a 100-year storm to $745.4 million for a 500-year storm (see Table 39).

The Floods of March 2010

The most severe recent flooding occurred during the major storms of March 2010, when the Suffolk County broke the record of 11 inches of rain set in 1953. The Blue Hill Observatory recorded 17.7 inches of rain from three storms in the 19 days from March 13 to 31.

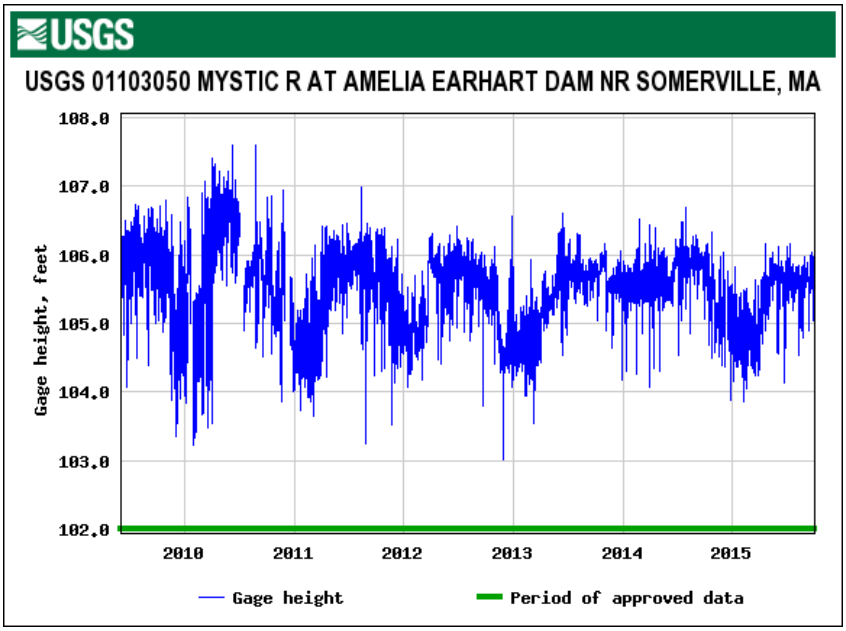
The weather pattern that caused these floods consisted of early springtime prevailing westerly winds that moved three successive storms, combined with tropical moisture from the Gulf of Mexico, across New England. Torrential rain falls lasting ten days caused March 2010 to be the wettest month on record for Suffolk County and Chelsea. Historically, NWS determined that March 2010 was the fourth wettest of any month since 1872.

One indication of the extent of flooding is the level of flow in the Mystic River during this record flood. Based on USGS gage height data, Figure 9 shows that the Mystic River at the Amelia Earhart Dam exceeded 107 feet after the first storm on March 10, and the cumulative impact of multiple storms kept river levels high into April. Figure 9 also shows the gage height normally does not exceed 107 feet, as shown for 2011- 2015.

The historic March 2010 rainstorms fit the profile of a type of event expected to increase in frequency as the climate warms. That is, significant precipitation, falling in late winter as rain rather than snow, on ground saturated with snow melt, and while vegetation is still dormant.

The March 2010 storms were a federally declared disaster making federal assistance available to residents who did not carry flood insurance. Based on the claims, Chelsea experienced moderate flood damage, with 11 disaster claims. All but one of the claims were located outside of FEMA Special Flood Hazard Areas, and not associated with waterways. This is not unusual in urbanized areas. See Map xx in Appendix A for claim locations.

Figure 9 - Mystic River USGS Gage Height, March 2010 Floods



Source: USGS National Water Information System

Information on flood hazard areas in Chelsea was taken from two sources. The first is the National Flood Insurance Rate Maps (FIRM). The second the local Hazard Mitigation Team.

FEMA Flood Hazard Areas

The FIRM flood zones are shown on Map 3 in Appendix A and the FIRM zone definitions are shown below:

Zones A1-30 and AE: Special Flood Hazard Areas subject to inundation by the 1-percent-annual-chance flood event determined by detailed methods. Base Flood Elevations are shown within these zones.

Zone A: Special Flood Hazard Areas subject to inundation by the 1-percent-annual-chance flood event are determined using approximate methodologies. Because detailed hydraulic analyses are not performed, no Base Flood Elevations or depths are shown.

Zone AO: Special Flood Hazard Areas subject to inundation by 1-percent-annual-chance shallow flooding (usually sheet flow on sloping terrain) where average depths are between one and three feet. Average flood depths derived from detailed hydraulic analyses are shown in this zone.

Zone B and X (shaded): Zones where the land elevation as been determined to be above the Base Flood Elevation, but below the 500-year flood elevation. These zones are not Special Flood Hazard Areas.

Zones C and X (unshaded): Zones where the land elevation has been determined to be above both the Base Flood Elevation and the 500-year flood elevation.

Based on the current FEMA Flood Insurance Rate Maps available for Chelsea (Suffolk County, MA, 2016), the following areas are in "100-year" flood hazard zones, which FEMA defines as an area with a 1% annual chance of flooding:

- The low-lying wetland areas bordering the upper Chelsea Creek area, particularly in the Clinton Street and Garfield Avenue neighborhoods
- Land along Chelsea Creek parallel to Crescent Avenue, Eastern Avenue and Marginal Street
- Along the Mystic River adjacent to Beacham Street

Locally Identified Flooding Sites

The local areas of flooding listed in below were identified by City staff as areas where flooding is known to occur. These areas do not necessarily coincide with the flood zones from the FIRM maps. They may be areas that flood due to inadequate drainage systems or other local conditions rather than location within a flood zone. The numbers of each area correspond to the numbers on Map 3.

4. ***Vale Street neighborhood***: flooding due to insufficient drain line receiving storm water from Everett and ultimately draining to clogged Island End culvert- High priority project.

2. ***Willow Street between Congress and Maverick Streets***: This is a low elevation area where fresh water runoff is unable to drain due to high tide and surge blocking the storm drain. This area needs a new pump station and has an estimated cost of $2-3 million dollars. The flooding does not impact residential properties but may affect redevelopment of the vacant 30,000 SF abandoned Nancy Sales building in the area.

3. ***Eastern Avenue at Webster Street neighborhood***: A low elevation area that floods when high tides combine with high precipitation events to back up storm line drainage. Mitigation may include reducing stormwater runoff using Green Infrastructure in upper watershed/drainage areas to reduce flows to the site, in addition to another pump station for the area. Total cost anticipated to be $5-6 million, to be paid by Chelsea.

4. ***Drainage ditch next to Chelsea Housing Authority***: Clogged drainage ditch floods during high precipitation events. This ditch is owned and maintained by MA DOT, is located in Revere but causes localized flooding in Chelsea—regional problem

Simulated Flooding Sites

In addition to the flooding sites identified by the Hazard Mitigation Team, the City conducted a drainage analysis using a hydraulic model to simulate potential future flooding areas under a 100-year storm and a climate change scenario for the year 2070. The analysis identified xx sites where manholes are projected to surcharge, and xx sites that would be inundated. The sites were also added to Map 3, numbered 15 through 38, and are listed below:

Table 8: Simulated Local Flooding Sites in Chelsea

Map #	Simulated Flooding Sites
15	Manhole surcharge
16	Manhole Surcharge
17	Manhole surcharge
18	Manhole surcharge, Dudley St & Crescent Ave
19	Storm sewer backup, Chestnut & Walnut St
20	Simulated flooding over 1 ft depth
21	Manhole surcharge, 6th Street
22	Manhole surcharge + simulated flooding deeper than 1 ft
23	Simulated flooding deeper than 1 ft
24	Simulated flooding deeper than 1 ft
25	Simulated flooding deeper than 1-ft
26	Simulated flooding deeper than 1 ft
27	Manhole surcharge + simulated flooding deeper than 1 ft
28	Manhole surcharge & simulated flooding deeper than 1 ft
29	Manhole surcharge, coastal & street flooding deeper than 1 ft
30	Manhole surcharge
31	Manhole surcharge, 4th Street
32	Manhole surcharge
33	Manhole surcharge
34	Manhole surcharge
35	Manhole surcharge
36	Manhole surcharge
37	Manhole surcharge + flooding deeper than 1 ft
38	Manhole surcharge & flooding deeper than 1 ft

Source City of Chelsea Hydraulic Analysis

Repetitive Loss Properties

Another indicator of flood risk is repetitive loss properties. As defined by the Community Rating System (CRS) of the National Flood Insurance Program (NFIP), a repetitive loss property is any property for which the NFIP has paid two or more flood claims of $1,000 or more in any given 10-year period since 1978. For information on repetitive losses see:
https://www.fema.gov/repetitive-flood-claims-grant-program-fact-sheet
There is one repetitive loss property in Chelsea. Flood insurance claims for building losses and contents losses are shown in Table 9.

Table 9 - Repetitive Loss Property Summary

Property	Number of Claims	Building Losses	Contents Losses	Total Losses Paid
2-4 Family	3	$14,561.03	$10,997.50	$25,558.53

Source: Federal Emergency Management Agency, National Flood Insurance Program

Based on the record of previous occurrences flooding events in Chelsea are a high frequency event as defined by the Massachusetts State Hazard Mitigation Plan. This hazard may occur more frequently than once in five years, or a greater than 20% chance per year.

ICE JAMS

Ice jams occur in cold weather when normally flowing water freezes, effectively damming the waterway and causing localized flooding. Flooding may also occur when ice jams break up and ice may pile up at culverts or around bridges. Given the tidal waters surrounding Chelsea, there is no record of ice jams in the City, and the local team did not identify this hazard as an issue for the City.

COASTAL FLOODING

Coastal flooding is associated with severe coastal storms that, through the combination of winds and tides, drive tidal waters to higher levels than normally experienced, leading to the inundation of low-lying land areas and the overtopping of sea walls. Also, the high tide and storm surge can limit the ability of stormwater to drain from inland waterways. Coastal flood and storm surge records for Suffolk County are shown in Table 10. Property damages from 2001 to 2021 totaled $49 million. Some of Chelsea's flooding is directly related to this type of flooding including the Willow Street and Eastern Avenue sites identified in this plan.

Table 10 – Suffolk County Coastal Flood/Storm Surges, 2001-2021

Date	Type	Deaths	Injuries	Property Damage
3/5/2001	Coastal Flood	0	0	$15.0M
11/6/2002	Storm Surge	0	0	$10K
1/4/2003	Storm Surge	0	0	$250K
12/6/2003	Storm Surge	0	0	$10K
1/23/2005	Storm Surge	0	0	$100K
5/24/2005	Storm Surge	0	0	$15K
5/25/2005	Storm Surge	0	0	$10K
1/31/2006	Coastal Flood	0	0	$10K
2/12/2006	Storm Surge	0	0	$15K
4/15/2007	Coastal Flood	0	0	$5K
4/16/2007	Coastal Flood	0	0	$5K
4/17/2007	Coastal Flood	0	0	$10K
10/18/2009	Coastal Flood	0	0	0
1/2/2010	Coastal Flood	0	0	0
3/14/2010	Coastal Flood	0	0	0
12/27/2010	Coastal Flood	0	0	$50K
8/27/2011	Storm Surge	0	0	0
11/23/2011	Coastal Flood	0	0	0
06/03/2012	Coastal Flood	0	0	0
06/04/2012	Coastal Flood	0	0	0
10/29/2012	Coastal Flood	0	0	$3.0M
2/9/2013	Coastal Flood	0	0	$30.0M
3/7/2013	Coastal Flood	0	0	00

1/2/2014	Coastal Flood	0	0	0
1/3/2014	Coastal Flood	0	0	0
8/13/2014	Coastal Flood	0	0	0
10/23/2014	Coastal Flood	0	0	0
1/27/2015	Coastal Flood	0	0	0
10/28/2015	Coastal Flood	0	0	0
1/24/2016	Coastal Flood	0	0	0
2/8/2016	Coastal Flood	0	0	0
1/4/2018	Coastal Flood	0	0	$500K
1/30/2018	Coastal Flood	0	0	$20K
3/2/2018	Coastal Flood	0	0	0
10/27/2018	Coastal Flood	0	0	0
11/25/2018	Coastal Flood	0	0	0
1/20/2019	Coastal Flood	0	0	0
10/28/2019	Coastal Flood	0	0	0
4/3/2020	Coastal Flood	0	0	0
4/9/2020	Coastal Flood	0	0	0
9/22/2020	Coastal Flood	0	0	0
12/17/2020	Coastal Flood	0	0	0
2/2/2021	Coastal Flood	0	0	0
7/23/2021	Coastal Flood	0	0	0
TOTAL		**0**	**0**	**$49M**

Source: NOAA, National Centers for Environmental Information

Climate Change Impacts: Sea-level Rise

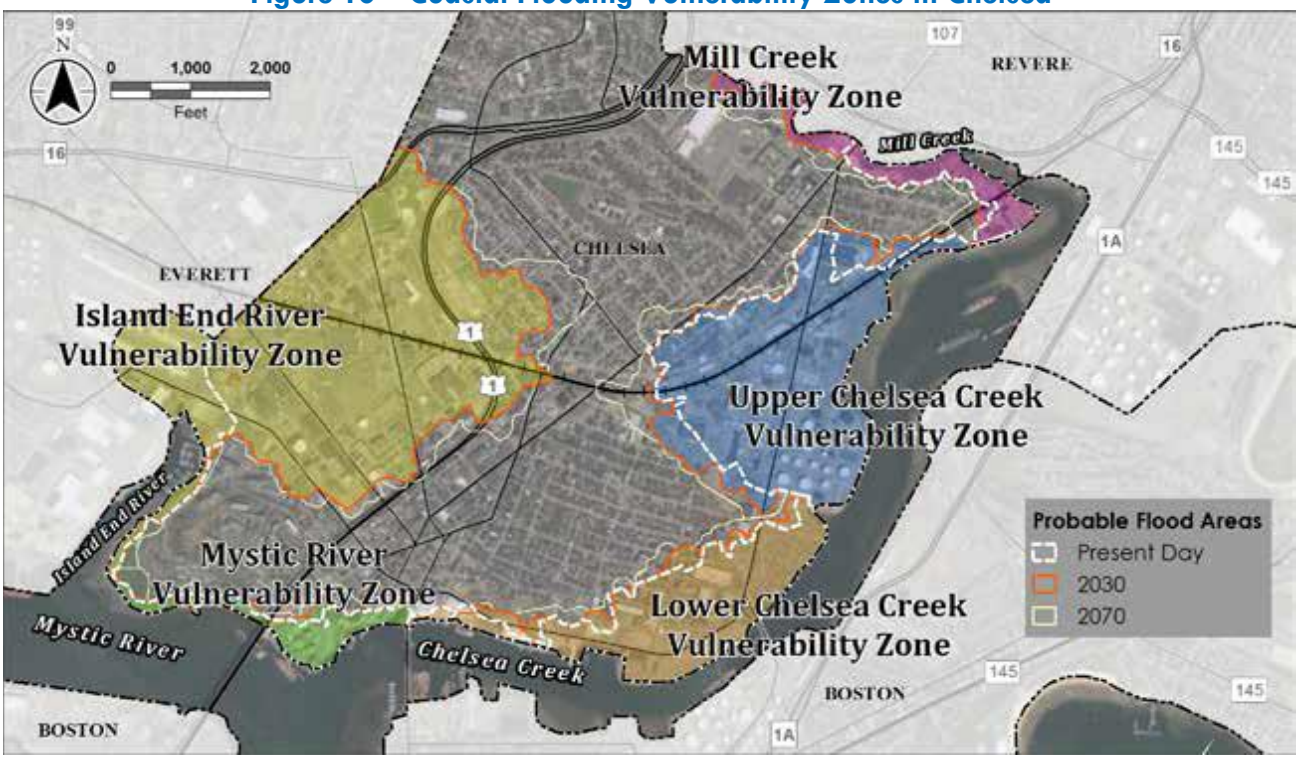
Higher sea levels increase the frequency and extent of coastal flooding. In the past 100 years, the relative change in sea level in Boston Harbor adjacent to Chelsea has been about one foot (Figure 7). The change is relative, because it consists of two components: a rise in the absolute sea level and a subsidence or sinking of the land following the last period of glaciers. In the past 100 years, these two factors have been roughly equal, and, for the most part, represent long-term processes that have been underway since the end of the last Ice Age, approximately 14,000 years ago.

Climate change is accelerating the rate of global sea-level rise primarily by warming the oceans, causing the water to expand in volume, and also by warming the land and air, causing ice on land (glaciers, ice sheets) to melt and flow into the ocean. Projections of future Sea Leve Rise in the State Hazard Mitigation and Climate Adaptation Plan (Figure 8), estimate a range of approximately 1.5 to 3 feet for the yar 2050. For the year 2100, the range is from 4 feet to 10 feet.

Coastal flooding occurs when the wind and tides overtop the shoreline and inundate low-lying areas. With an average elevation of less than ten feet above sea level, it is not surprising that approximately 20% of the City is mapped within a potential coastal flooding in present day. Add on sea level rise projections of 0.6 feet in 2030 and 3.2 feet in 2070, and anticipated more frequent and intense storm events, this percentage increases to 35% in 2030 and 45% in 2070.

To evaluate the additional risks and impacts of future Seal Level Rise, the City prepared a comprehensive vulnerability assessment in 2017, *Designing Coastal Community Infrastructure for Climate Change*. The study identified five areas of the City at risk for coastal flooding caused by Sea Level Rise: Island End River, Mystic River, Lower Chelsea Creek, Upper Chelsea Creek, and Mill River. These areas are highlighted in Figure 10.

Figure 10 – Coastal Flooding Vulnerability Zones in Chelsea

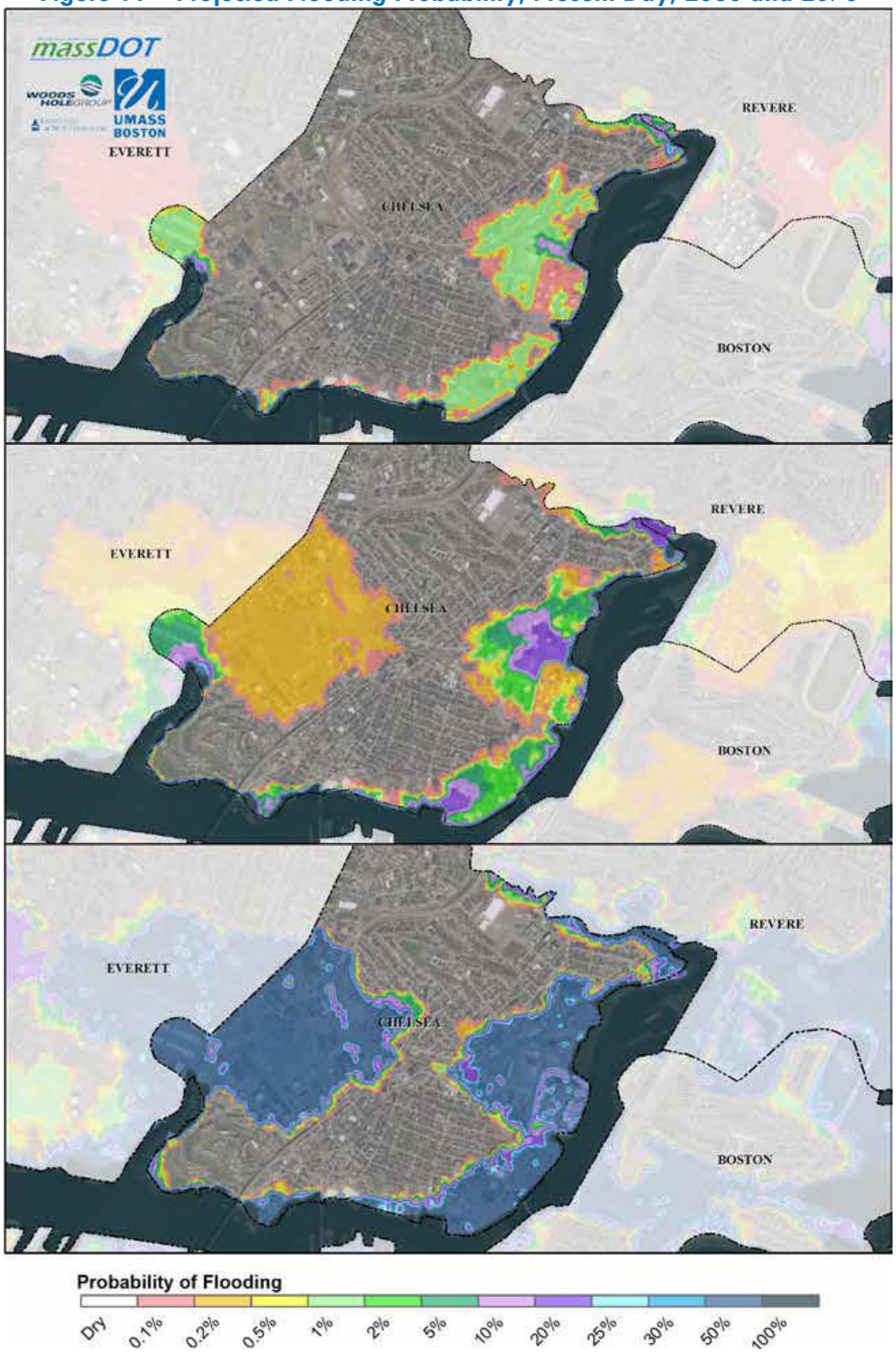


Source: *Designing Coastal Community Infrastructure for Climate Change*

Chelsea's planning for sea level rise utilized the Boston Harbor Flood Risk Model (BH-FRM) to determine which areas of the City are most vulnerable to coastal flooding. The BH-FRM is a probabilistic, dynamic model, meaning that it includes the physical processes associated with storm events (e.g., waves, winds, tides, storm surge, etc.) and not just static increases in water levels BH-FRM also assesses future flood risk based on sea level rise projections and a range of potential storm events. This is the same model being used by other metro-Boston area municipalities, Massachusetts Department of Transportation (MassDOT), Massachusetts Port Authority, and other agencies.

The model determines key flood pathways where coastal flood waters are predicted to enter the City. The five flooding vulnerability zones in Chelsea collectively represent 36% of the City's area for present day, 42% of the City in 2030 and 49% of the City in 2070 (Figure 11).

Figure 11 – Projected Flooding Probability, Present Day, 2030 and 2070



Source: *Designing Coastal Community Infrastructure for Climate Change*

The vulnerability analysis identified several key public infrastructure facilities located within the five coastal flood hazard zones. These are summarized in Table 11.

Table 11 – Chelsea Critical Facilities in Coastal Flood Hazard Zones

Facility	Sector	Vulnerability Zone	Owner
MWRA Chelsea Creek Headworks and Screen House	Wastewater	Lower Chelsea Creek	MWRA
Chelsea Street Bridge over Chelsea Creek	Transportation	Lower Chelsea Creek	MassDOT
MWRA Chelsea Facility	Water and Wastewater	Upper Chelsea Creek	MWRA
Railroad Bridge over Mill Creek	Transportation	Mill Creek	MassDOT
Substation #488 at Willoughby St.	Energy	Upper Chelsea Creek	MBTA
Carter Street Pump Station	Stormwater	Island End River	Eversource
Williams Middle School	Buildings	Island End River	City
City Yard	Buildings	Island End River	City
Burke School Complex	Buildings	Upper Chelsea Creek	City
Chelsea High School	Buildings	Island End River	City
Meridian Street Bridge over Chelsea Creek	Transportation	Lower Chelsea Creek	MassDOT
Broadway Bridge over Mill Creek	Transportation	Mill Creek	MassDOT

Source: *Designing Coastal Community Infrastructure for Climate Change*

Based on the record of previous occurrences flooding events in Chelsea are a high frequency event as defined by the Massachusetts State Hazard Mitigation Plan. This hazard may occur more frequently than once in five years, or a greater than 20% chance per year. As the climate projections show, the frequency is expected to increase in the coming years and decades.

DAM FAILURE

Dam failure can occur as a result of structural failure, independent of a hazard event, or as the result of the impacts of a hazard event such as flooding associated with storms or an earthquake. In the event of a dam failure, the number of fatalities and amount of property damages depends on the amount of warning provided to the population and the number of people and value of property in the path of the dam's floodwaters. Dam failure in general is infrequent but has the potential for severe impacts.

There are no dams located within the City of Chelsea. The closest dam to Chelsea is the Amelia Earhart Dam, located just east of the confluence of the Mystic River and the Malden River, was constructed in 1966 between Everett and Somerville. The dam was built to control upstream tidal flooding and to create a freshwater basin for public recreation. The Charles River Dam, rebuilt in 1978, controls river flow and flooding, and fills the Charles River Basin between Boston and Cambridge, a popular urban recreational area. Because these dams do not directly impact the City of Chelsea and there are no dams located within Chelsea proper, the City did not include mitigation actions in its plan.

Based on the record of no previous occurrences, dam failure in Chelsea is a Very Low frequency event as defined by the Massachusetts State Hazard Mitigation Plan. This hazard may occur less frequently than once in 100 years (less than 1% chance per year).

DROUGHT

At the other end of the hydrologic spectrum from extreme precipitation is drought. Drought is a temporary irregularity in precipitation and differs from aridity since the latter is restricted to low rainfall regions and is a permanent feature of climate. Drought is a period characterized by long durations of below normal precipitation. Drought conditions occur in virtually all climatic zones, yet its characteristics vary significantly from one region to another since it is relative to the normal precipitation in that region. Drought can affect agriculture, water supply, aquatic ecology, wildlife, and plant life.

In Massachusetts, droughts are caused by the prevalence of dry northern continental air and a decrease in coastal- and tropical-cyclone activity. During the 1960's, a cool drought occurred because dry air from the north caused lower temperatures in the spring and summer of 1962-65. The northerly winds drove frontal systems to sea along the Southeast Coast and prevented the Northeastern States from receiving moisture (U.S. Geological Survey). This is considered the drought of record in Massachusetts.

Average annual precipitation in Massachusetts is 44 inches per year, with approximately 3 to 4 inches average amounts for each month of the year. Regional monthly precipitation ranges from zero to 17 inches. Statewide annual precipitation ranges from 30 to 61 inches. Thus, in the driest calendar year (1965), the statewide precipitation total of 30 inches was 68 percent of average.

Although Massachusetts is relatively small, it has a number of distinct regions that experience significantly different weather patterns and react differently to the amounts of precipitation they receive. The 2019 Massachusetts Drought Management Plan divides the state into seven regions: Western, Central, Connecticut River Valley, Northeast, Southeast, and Cape Cod, and Islands. Chelsea is located in the Northeast region. Drought is a potential city-wide hazard in Chelsea.

The MA Drought Management Plan was revised in 2019 to change the state's classification of droughts by establishing four levels to characterize drought severity: Mild Drought, Significant Drought, Critical Drought, and Emergency. These levels are based on conditions of natural resources and provide information on the current status of water resources. The levels provide a framework from which to take actions to assess, communicate, and respond to drought conditions. The Massachusetts drought levels are shown in comparison to the U.S. Drought Monitor levels in Table 12. The two sets of drought indices are similar, but Massachusetts combines the USDM's level D2 and D3 into one category, Critical Droughts.

Table 12: MA Statewide Drought Levels Compared to US Drought Monitor

USDM Names	Recurrence	Percentile Ranges	MA DMP Levels	MA Percentile Ranges	MA DMP Names
D0: Abnormally Dry	once per 3 to 5 years	21 to 30	1	>20 and ≤30%	Mild Drought
D1: Moderate	once per 5 to 10 years	11 to 20	2	>10 and ≤20%	Significant Drought
D2: Severe Drought	once per 10 to 20 years	6 to 10	3	>2 and ≤10%	Critical Drought
D3: Extreme Drought	once per 20 to 50 years	3 to 5			
D4: Exceptional Drought	once per 50 to 100 years	0 to 2	4	≤2%	Emergency

Source: Massachusetts Drought Management Plan, 2019

Water restrictions might be appropriate at the significant drought stage, depending on the capacity of each individual water supply system. A critical drought level indicates a severe situation and the possibility that a drought emergency may be necessary. A drought emergency is one in which mandatory water restrictions or use of emergency supplies is necessary. Drought levels are used to coordinate both state agency and local response to drought situations.

As dry conditions can have a range of different impacts, a number of drought indices are available to assess these various impacts. Massachusetts uses a multi-index system that takes advantage of several of these indices to determine the severity of a given drought or extended period of dry conditions. Drought level is determined monthly based on the number of indices which have reached a given drought level. Drought levels are declared on a regional basis for each of six regions in Massachusetts. County by county or watershed-specific determinations may also be made. A determination of drought level is based on seven indices:

1. Standardized Precipitation Index (SPI) reflects soil moisture and precipitation.
2. Crop Moisture Index: (CMI) reflects soil moisture conditions for agriculture.
3. Keetch Byram Drought Index (KBDI) is designed for fire potential assessment.
4. Precipitation Index is a comparison of measured precipitation amounts to historic normal precipitation.
5. The Groundwater Level Index is based on the number of consecutive month's groundwater levels are below normal (lowest 25% of period of record).
6. The Stream flow Index is based on the number of consecutive months that stream flow levels are below normal (lowest 25% of period of record).
7. The Reservoir Index is based on the water levels of small, medium, and large index reservoirs across the state, relative to normal conditions for each month.

Table 13 shows the range of values for each of the indices associated with the drought levels. Because drought tends to be a regional natural hazard, this plan references state data as the best available data for previous drought occurrences.

Table 13: Indices Values Corresponding to Drought Index Severity Levels

Index Severity Level	Standardized Precipitation Index	Streamflow	Lakes and Impoundments	Groundwater	Keetch-Byram Drought Index	Crop Moisture Index
0	>30th percentile				< 200	> -1.0
1	≤30 and >20				200-400	≤-1.0 and > -2.0
2	≤20 and >10				400-600	≤-2.0 and < -3.0
3	≤10 and >2				600-700	≤ -3.0 and > -4.0
4	≤2				700-800	≤-4.0

Source: Massachusetts Drought Management Plan, 2019

Determinations regarding the end of a drought or reduction of the drought level focus on two key drought indicators: precipitation and groundwater levels. These two factors have the greatest long-term impact on stream flow, water supply, reservoir levels, soil moisture and potential for forest fires.

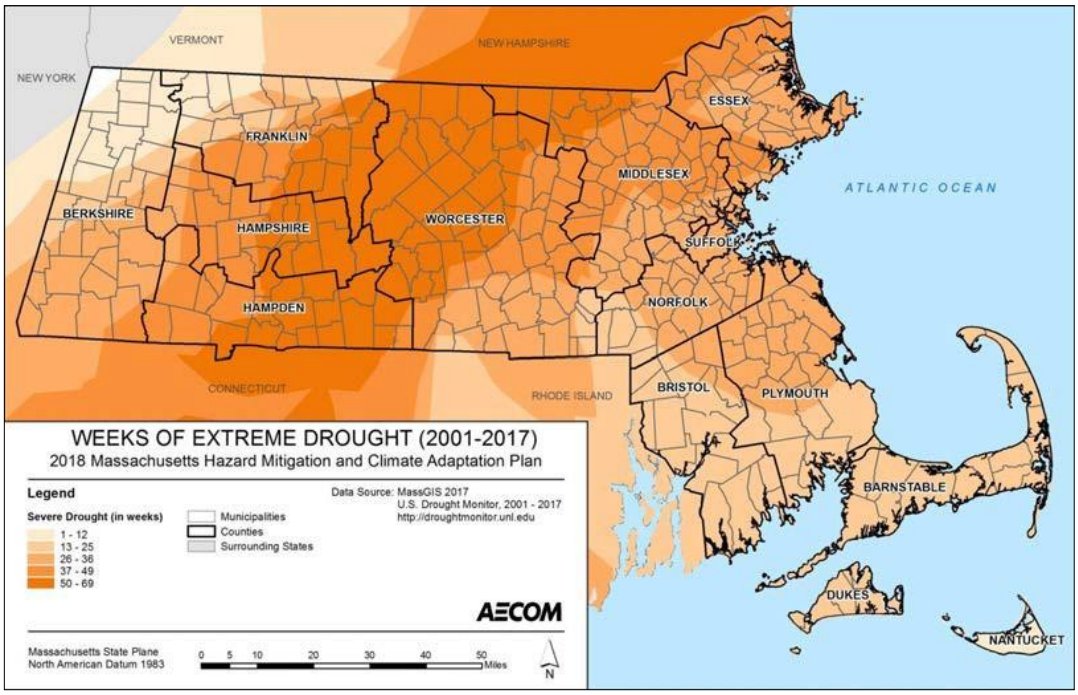
Previous Occurrences of Drought

Drought emergencies have been reached infrequently, with five events occurring between 1850 and 2012: 1883, 1911, 1941, 1957, and 1965 to 1966. Due to its long duration, the drought from 1965 to 1966 is viewed as the most severe drought to have occurred in Massachusetts in modern times. The drought that extended from July 2016 to April 2017 reached the Drought Warning level.

The U.S. Drought Monitor characterizes droughts as moderate, severe, extreme, or exceptional. Severe drought is characterized by likely crop and pasture losses, water shortages, and water restrictions. As shown in Figure 12 below, Chelsea experienced between 26 and 36 weeks of severe drought between 2001 and 2017.

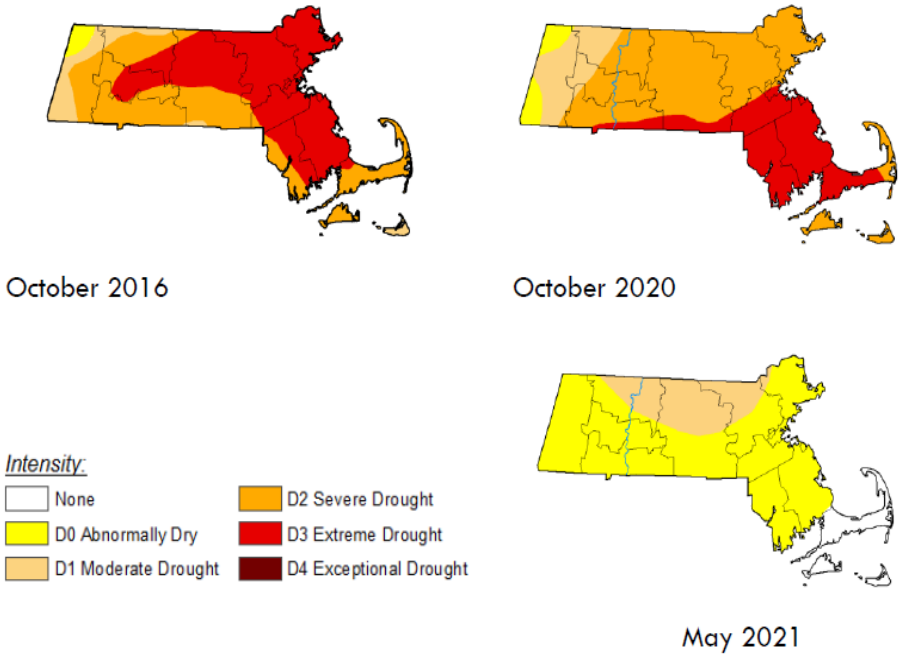
In the last five years there have been three droughts in Massachusetts. The drought of 2016 was the worst one since 1985, with more than half of the state reaching the Extreme Drought stage for several months (Figure 13). This was followed by another drought just four years later in 2020, which was most severe in Southeastern Massachusetts and somewhat less so in Chelsea. Finally, in the early spring of 2021 a third, milder, drought was declared. By the summer of 2021 conditions in the northeast region improved.

Figure 12: Weeks of Severe Drought (2001-2017)



Source: SHMCAP

Figure 13: Recent Drought Events (2016-2021)



Source: U.S. Drought Monitor

Potential Drought Vulnerability

Chelsea's potential vulnerability to a severe long-term drought could be a reduction in the availability of water supplies, which in turn could affect public health and economic activity. However, the City is a member of the Massachusetts Water Resources Authority (MWRA). Given the resilience of the MWRA system due to the exceptionally large amount of storage in the Quabbin and Wachusett Reservoirs, severe impacts of drought on the City of Chelsea have never occurred and are unlikely.

Probability of Future Occurrences

Because drought tends to be a regional natural hazard, this plan references state data as the best available data for drought. Drought is potentially a city-wide hazard in Chelsea. The SHMCAP using data collected since 1850, calculates that statewide there is a 1% chance of being in a drought emergency in any given month. For drought warning and watch levels, the chance is 2% and 8% respectively in any given month (Table 14).

Table 14: Frequency of Massachusetts Drought Levels

Drought Level	Frequency Since 1850	ɔability of Occurrence in a Given Month
Drought Emergency	5 occurrences	1% chance
Drought Warning	5 occurrences	2% chance
Drought Watch	46 occurrences	8% chance

Droughts and Climate Change

Droughts are projected to increase in frequency and intensity in the summer and fall as weather patterns change. Factors contributing to this include increasing evaporation as a result of warmer weather, earlier snow melt, and more extreme weather patterns. Drought impacts can include reduced groundwater and surface water levels, affecting water quality and quantity, and the organisms that rely on aquatic resources. Drought also increases stress on plant communities and, the likelihood of forest and brush fires. Communities may be affected by water use restrictions, affecting drinking water supply and outdoor water use. Economic sectors impacted could include recreation, agriculture, and forestry.

LANDSLIDES

According to the U.S. Geological Survey, "The term landslide includes a wide range of ground movement, such as rock falls, deep failure of slopes, and shallow debris flows. Although gravity

acting on an over steepened slope is the primary reason for a landslide, there are other contributing factors." Among the contributing factors are, erosion by rivers or ocean waves over steepened slopes; rock and soil slopes weakened through saturation by snowmelt or heavy rains; earthquake created stresses that make weak slopes fail; excess weight from accumulation of rain or snow; and stockpiling of rock or ore from waste piles or man-made structures. In Massachusetts, according to the SHMCAP, the most common cause of landslides are geologic conditions combined with steep slopes and/or heavy rains. Landslides associated with heavy rains typically occur on steep slopes with permeable soils underlain by till or bedrock.

Landslides can result from human activities that destabilize an area or can occur as a secondary impact from another natural hazard, such as flooding. In addition to structural damage to buildings and the blockage of transportation corridors, landslides can lead to sedimentation of water bodies. Typically, a landslide occurs when the condition of a slope changes from stable to unstable. Natural precipitation such as heavy snow accumulation, torrential rain, and run-off may saturate soil, creating instability enough to contribute to a landslide. Drought may also increase the likelihood of landslides if loss of vegetation decreases soil stability.

In Massachusetts, according to the SHMCAP, the most common cause of landslides are geologic conditions combined with steep slopes and/or heavy rains. Landslides associated with heavy rains typically occur on steep slopes with permeable soils underlain by till or bedrock.

There is no universally accepted measure of landslide extent, but it has been represented as a measure of the destructiveness. Table 15 summarizes the estimated intensity for a range of landslides. Fast moving rock falls have the highest intensity while slow moving landslides have the lowest intensity.

Table 15 Landslide Volume and Velocity

Estimated Volume	Expected Landslide Velocity		
	Fast moving (rock	Rapid moving (debris	Slow moving
<0.001	Slight intensity	--	--
<0.5	Medium intensity	--	--
>0.5	High intensity	---	--
<500	High intensity	Slight intensity	--
500-	High intensity	Medium intensity	Slight intensity
10,000 – 50,000	Very high intensity	High intensity	Medium intensity
>500,000	--	Very high intensity	High intensity
>500,000	--	--	Very high intensity

Source: *A Geomorphological Approach to the Estimation of Landslide Hazards and Risks in Umbria, Central Italy*, M. Cardinali et al, 2002

The SHMCAP, utilized data from the MA Department of Transportation from 1986 to 2006 to estimates that, on average, roughly one to three known landslides have occurred each year in the state. A slope stability map published by the MA Geological Survey and UMass-Amherst indicates that the most significant risk of landslide is in western Massachusetts. According to the SHMCAP, factors that influence landslide severity include soil properties, topographic position and slope, and historical incidence.

The entire City of Chelsea is classified as having moderate susceptibility and a low incidence of landslides (see Map 4, Appendix A). In Chelsea the primary concern is not landslides in natural landscapes, but rather potential failure of retaining walls in developed areas. Should a landslide occur in the future, the type and degree of impacts would be highly localized. The city's vulnerabilities could include damage to structures, damage to transportation and other infrastructure, and localized road closures. Injuries and casualties, while possible, would be unlikely given the low extent and impact of landslides in Chelsea.

Based on past occurrences in Chelsea, landslides are very low frequency events that can occur less frequently than once in 100 years (less than 1% per year).

Climate Change and Landslides

Changes in precipitation may increase the chance of landslides, as extreme rain events could result in more frequent saturated soils which are conducive to landslides. Drought may also increase the likelihood of landslides if loss of vegetation decreases soil stability.

RISING TEMPERATURES

AVERAGE AND EXTREME TEMPERATURES

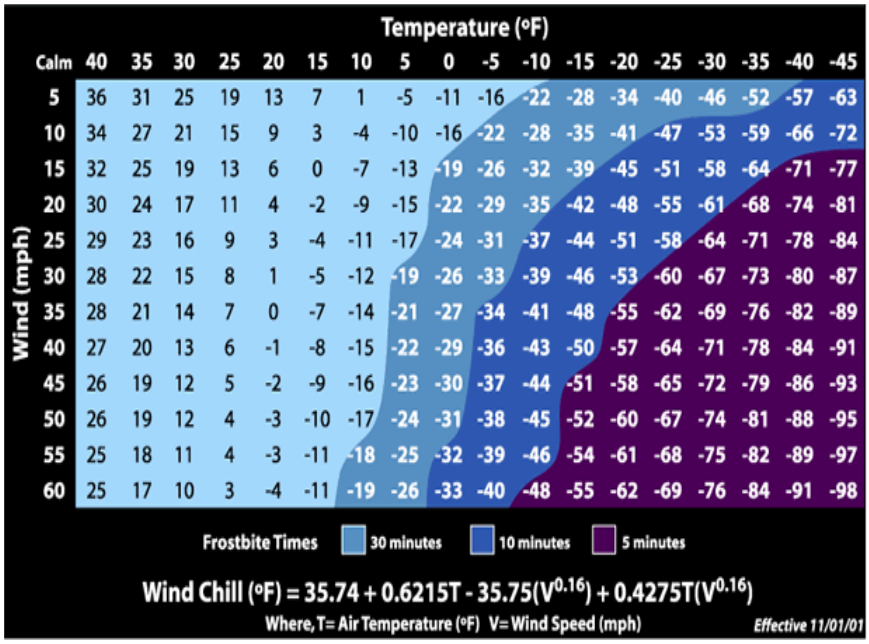
Extreme temperatures occur when either high temperature or low temperatures relative to average local temperatures occur. These can occur for brief periods of time and be acute, or they can occur over extended periods of time where there is a long stretch of excessively hot or cold weather. Chelsea has four well-defined seasons. The seasons have several defining factors, with temperature one of the most significant. Extreme temperatures can be defined as those that are far outside of the normal seasonal ranges for Massachusetts.

EXTREME COLD

The severity of extreme cold temperature is typically measured using the Wind Chill Temperature Index (Figure 14), which is provided by the National Weather Service (NWS). The wind chill is the apparent temperature felt on exposed skin due to the combination of air temperature and wind speed. The index is provided in Figure 14 below. A Wind Chill warning is issued when the Wind Chill Index is forecast to fall below -25 degrees F for at least 3 hours.

Extreme cold is a dangerous situation that can result in health emergencies for susceptible people, such as those without shelter, those who are stranded, or those who live in homes that are poorly insulated or without heat. The best available local data on extreme cold events are recorded for Suffolk County through the National Centers For Environmental Information (NCEI). As shown in Table 16, there have been three reported extreme cold events, which caused one death, no injuries, or property damage.

Figure 14 Wind Chill Temperature Index and Frostbite Risk



Source: National Weather Service

Table 16: Suffolk County Extreme Cold Occurrences 2010 -2020

Date	Deaths	Injuries	Damages
2/3/2007	1	0	0
2/16/2015	0	0	0
2/14/2016	0	0	0

Source: NOAA, National Centers for Environmental Information

Impacts and Vulnerabilities of Extreme Cold

Chelsea's vulnerability to extreme cold events is primarily related to vulnerable populations, including children, the elderly, and those who have a physical disability or certain medical conditions. Extreme cold can result in health emergencies for susceptible people, such as those without shelter or who are stranded or who live in homes that are poorly insulated or without heat. The greatest vulnerability would be a power outage, which could temporarily leave many residents without heat. In Chelsea, 8.7% of residents are under the age of 5 and 9.5% are 65 years of age or older.

EXTREME HEAT

A heat wave in Massachusetts is defined as three or more consecutive days above 90°F. Another measure used for identifying extreme heat events relies on the Heat Index. According to the National Weather Service (NWS), the Heat Index is a measure of how hot it really feels relative humidity is factored in with the actual air temperature. The NWS issues an advisory when the heat index (Figure 15) is forecast to exceed 100°F for two or more hours; an excessive heat advisory is issued if the forecast predicts the temperature will rise above 105°F.

Figure 15: Heat Index Chart

Relative Humidity (%) \ Temperature (°F)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Category	Heat Index	Health Hazards
Extreme Danger	130 °F – Higher	Heat Stroke or Sunstroke is likely with continued exposure.
Danger	105 °F – 129 °F	Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity.
Extreme Caution	90 °F – 105 °F	Sunstroke, muscle cramps, and/or heat exhaustions possible with prolonged exposure and/or physical activity.
Caution	80 °F – 90 °F	Fatigue possible with prolonged exposure and/or physical activity.

Source: National Weather Service

Table 17: Suffolk County Extreme Heat Occurrences 2000 - 2020

Date	Deaths	Injuries	Damages
12/17/2000	0	0	0
5/3/2001	0	0	0
5/4/2001	0	0	0
5/12/2001	0	0	0
7/22/2011	0	0	0
7/3/2018	0	0	0

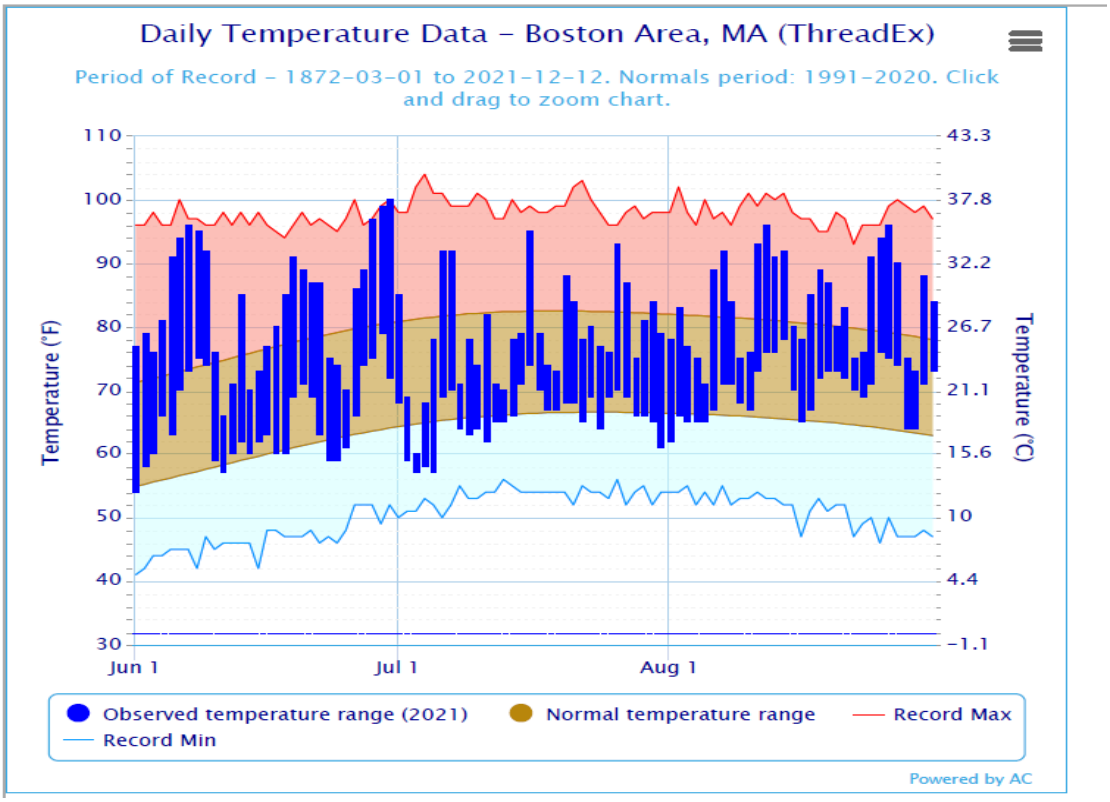
Source: NOAA, National Centers for Environmental Information

The one source of records of previous occurrences of extreme heat events is NOAA's National Centers For Environmental Information (NCEI), which records these events for Suffolk County. As shown in Table 17, there have been six reported extreme cold events, which caused no deaths, no injuries, or property damage.

Heat Waves

While the number of 90F+ days per year is a broad indication of extreme temperatures, an indicator that relates more directly to public health impacts is the occurrence of multiple-day heat waves, defined at three or more consecutive days with high temperatures 90F or higher. The most recent summer of 2021 was an example of this, as shown in Figure 16.

Figure 16: Summer 2021 Temperatures, Boston Area



Source: NOAA

The summer of 2021 was particularly hot, with four heat waves.. Two of these lasted for five days, one lasted four days, and one lasted three days. Overall, there were 24 days 90F or more, 17 of which occurred during the four heat waves. Reviewing similar records for the last decade, the number and duration of heat waves from 2010 to 2021 is summarized in Table 18.

Table 18: Heat Waves, 2010-2021, Boston Area

Year	Number of Heat Waves	Number of Days 90F+
2010	3	25
2011	2	13
2012	2	12
2013	3	18
2014	0	8
2015	1	14
2016	1	22
2017	2	12
2018	2	25
2019	2	15
2020	3	14
2021	4	24

Source: NOAA

The best available long-term data on extreme high temperatures in the Boston area are available from NOAA's NOWData (NOAA Online Weather Data). Historic records of the number of days per year with high temperatures 90F or more for the last 100 years were compiled and are displayed graphically in Figure 17 below. The long-term trend is for more extreme heat in recent years.

Urban Heat Island

Extreme heat events can be exacerbated in more densely settled locations and areas with a high proportion of impervious surfaces, which can lead to a 'heat island' effect that results in higher localized temperatures. Hot summer days can also worsen air pollution, especially in urban areas. In areas of the Northeast that currently face problems with smog, inhabitants are likely to experience more days that fail to meet air quality standards. Heat waves and lower air quality can threaten the health of vulnerable populations, Additionally, Chelsea is a densely settled municipality that is mostly urbanized, so city as a whole experiences vulnerability to extreme temperatures due to urban heat island effects.

Due to what is termed the Urban Heat Island effect (UHI), areas with less shade and more dark surfaces (pavement and roofs) will experience even hotter temperatures; these surfaces absorb heat during the day and release it in the evening, keeping nighttime temperatures warmer as well. Map 10 in Appendix A displays areas that are among the hottest 5% of land in the MAPC region based on land surface temperature derived from satellite imagery on July 13, 2016, when the high temperature at Logan Airport was 92°F. Additionally, Chelsea is a densely settled municipality that is mostly urbanized, so city as a whole experiences vulnerability to extreme temperatures due to urban heat island effects.

The City of Chelsea , through a Municipal Vulnerability Preparedness (MVP) Action Grant, conducted an assessment of urban heat with the technical assistance of Weston & Sampson and in collaboration with GreenRoots and the C-HEAT project conducted by GreenRoots and the Boston University School of Public Health. Weston and Sampson developed ambient air temperature and heat index maps using land surface temperature data along with ambient air temperature in order to identify "hot spots" throughout the City. Hot spots are areas that experience higher temperature than the overall average temperature due to impervious surfaces, lack of tree canopy, presence of non-reflective dark roofs, or because of their geographic location (away from a significant water body). The identified "hot spot" areas are shown on Figure 18. The red boundaries are the known areas of "hot spots" in the City under current conditions and the orange boundaries denote areas that are emerging "hot spots" based on land cover, roof materials, and the geographical location.

Figure 17: Annual Number of Days > 90F in the Boston Area1920 - 2021

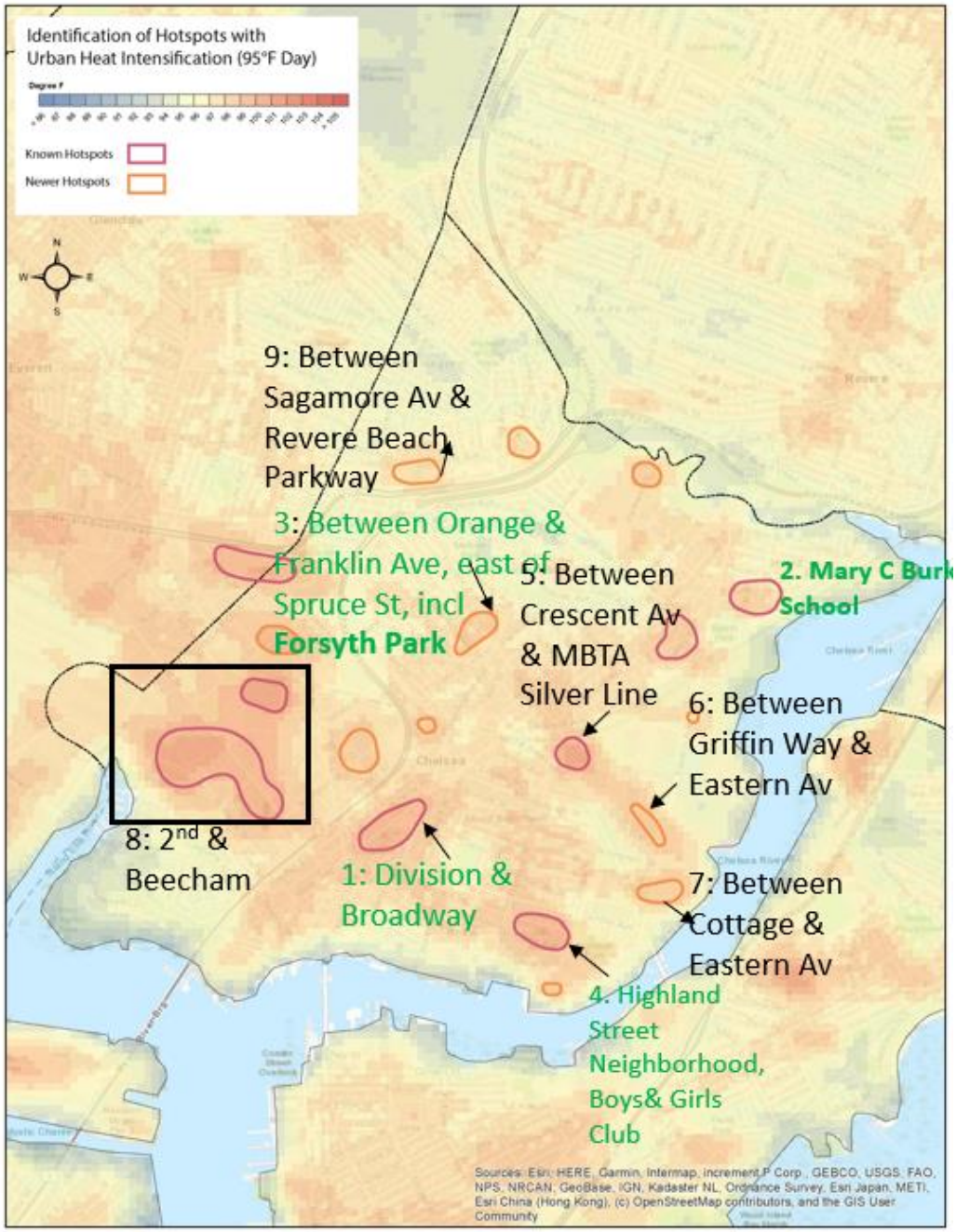
YEAR	#DAYS
1920	5
1921	13
1922	9
1923	12
1924	14
1925	13
1926	6
1927	6
1928	16
1929	15
1930	19
1931	17
1932	7
1933	16
1934	5
1935	4
1936	10
1937	16
1938	10
1939	10
1940	7
1941	18
1942	6
1943	17
1944	21
1945	8
1946	10
1947	10
1948	12
1949	22
1950	8
1951	6
1952	17
1953	15
1954	10
1955	28
1956	11
1957	11
1958	5
1959	22
1960	8
1961	14
1964	5
1963	16
1964	9
1965	9
1966	10
1967	3
1968	10
1967	11
1970	14
1971	15
1972	9
1973	19
1974	7
1975	15
1976	17
1977	18
1978	9
1979	12
1980	22
1981	11
1982	7
1983	30
1984	18
1985	4
1986	4
1987	9
1988	25
1989	7
1990	10
1991	27
1992	2
1993	20
1994	22
1995	17
1996	3
1997	19
1998	8
1999	16
2000	4
2001	16
2002	27
2003	6
2004	4
2005	14
2006	11
2007	18
2008	8
2009	6
2010	25
2011	13
2012	12
2013	18
2014	8
2015	14
2016	22
2017	12
2018	23
2019	15
2020	14
2021	24

Source: NOAA Online Weather Data (NOWData), compiled by MAPC

0-10 DAYS	11-15 DAYS	16 – 20 DAYS	20 -30 DAYS

The analysis shows the effect of UHI effect is more pronounced in the most urban areas of the City that have less tree canopy, more buildings, and are away from large water bodies (Figure 18). These areas are usually 2°-4° F warmer than the average ambient air temperature in the City. On the other hand, green areas with garden, parks, and lakes are usually cooler than the average.

Figure 18: Urban Heat Island Hotspots in Chelsea on a 95F Day



Source: Chelsea Urban Heat Island Model and Maps, Weston and Samson

Extreme Heat Impacts and Vulnerabilities

The impacts of extreme heat on Chelsea and several neighboring communities were evaluated by the Urban Land Institute in "Living With Heat," prepared in 2019. The report summarizes some of the key impacts as follows:

The rise in temperature in metropolitan areas is leading to an increase in health-related problems, particularly for children, the elderly, and economically disadvantaged groups. During extremely hot and humid weather, the ability of the body to cool itself is greatly diminished. So when the body heats too rapidly to cool itself properly, the body temperature rises, which can lead to fatigue, muscle cramps, heat exhaustion, fainting, and heat stroke. A series of consecutive days with warmer-than-average temperatures often results in more hospital admissions for respiratory, cardiovascular, and kidney-related diseases.

Many deaths are not directly attributed to heatstroke, but drastic increases in temperatures can turn preexisting conditions such as heart problems or lung disease fatal. In the Northeast, we can expect approximately 650 deaths per year by 2050.

Disparate impacts on Vulnerable Populations

Like many environmental health issues, the impacts of extreme heat are felt disproportionately across society. Unequally vulnerable communities include those who are challenged by poverty or homelessness, the elderly, young, socially isolated, and those who have preexisting medical conditions. African-American, Latino, and Asian communities are also considered higher risk groups, as are outdoor workers, including the construction industry.

Low-income communities are often underserved by green spaces that can mitigate urban heat and by civic amenities such as cooling facilities. Low-income communities are also less likely to have access to air conditioning and cooler recreational facilities such as swimming pools or gyms.

Effects of Extreme Heat on Cognition

While much of the research regarding health issues triggered by extreme heat focuses on the most vulnerable populations, there is also a significant impact on healthy adults and children in the form of impaired cognitive functioning, according to recent studies.

According to Dr. Joseph Allen, director of the Healthy Buildings Program at the Harvard T.H. Chan School of Public Health "We are all susceptible to the effects of heat stress and heat waves, even the young and healthy, and there are impacts beyond mortality, such as impaired cognitive functioning experienced as a result of indoor heat waves. This has implications for students as well as the business community."

Business Continuity

Extreme heat can contribute to other adverse events such as electrical grid failures, transportation interruptions, wildfires, and water shortages, all of which can cause human harm, business disruptions, and economic losses. Buildings and developments designed to be more prepared for these events have the potential to be more attractive to tenants, particularly in Class A office space, and may also eventually be eligible for preferable insurance rates. These types of weather-related continuity events also present risks because of potential property losses, tenant defaults, or both.

A report prepared for the nearby City of Somerville, *The Wellbeing of Somerville* (2017) describes how extreme heat has disproportionate health impacts on both the young and the elderly:

> Young children are more vulnerable to extreme heat, poor air quality and insect-borne diseases. One reason for this is their limited ability to communicate when overheating or left in dangerous situations. These impacts on children often have a ripple effect on families and economics. If schools or daycares are closed due to weather, parents need to find alternative childcare options. This may impact the ability of parents to work and, therefore, impact the family's income.
>
> Increases in temperature linked to climate change are projected to cause a correlating increase in the risk of insect-borne diseases such as Lyme disease and West Nile virus. Impacts to children's health can include a wide range of ongoing physical, behavioral, and cognitive problems.
>
> Elderly residents often have greater physical limitations during a climate event. These limitations include higher overall health vulnerability. As a result of these vulnerabilities, older individuals – across all income brackets – have a greater reliance on support services, including senior centers and cooling centers during high heat events. Elderly residents that live alone may be more socially isolated and lack reliable access to transportation, which can make it more difficult for them to access support services or evacuate during emergency events.
>
> Exposure to poor air quality, which is impacted by heat, traffic pollution and rising pollen levels, can be linked to cardiac and lung problems, as well as cognitive and memory issues in seniors, altering quality of life, as well as longevity. Older adults, especially frail or immune compromised adults, may also be more at risk for the increasing presence of insect borne diseases.

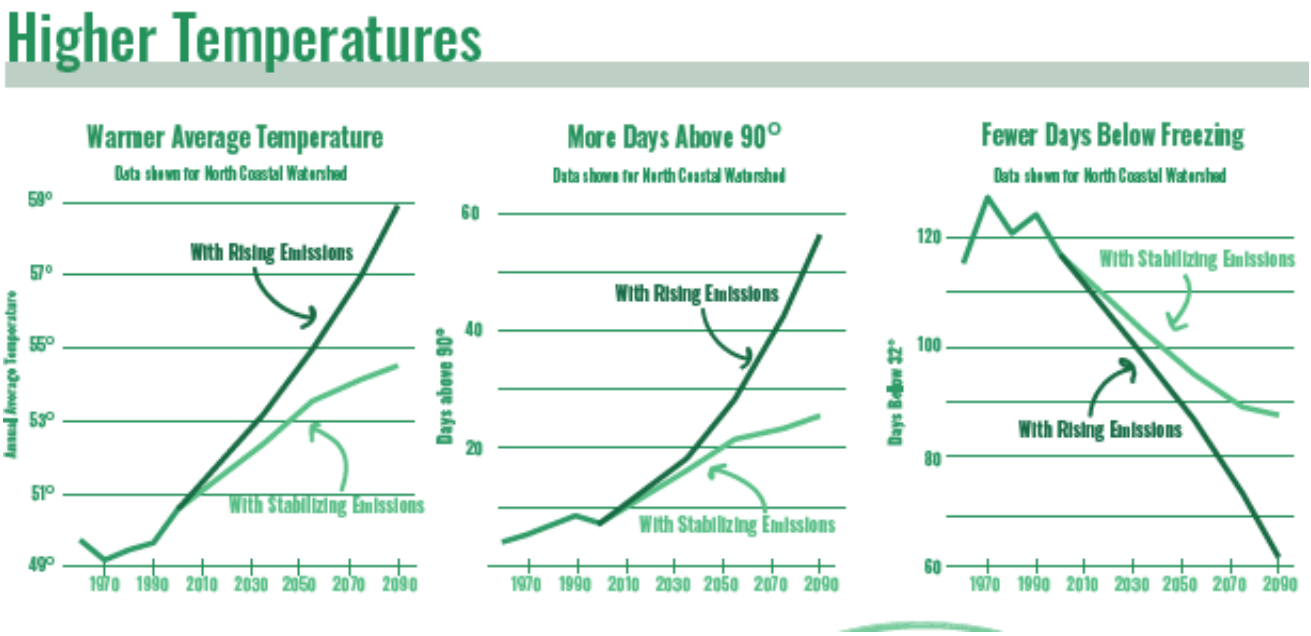
Probability of Future Occurrences

Based on the record of previous occurrences, extreme temperatures are a high frequency event as defined by the Massachusetts State Hazard Mitigation Plan. This hazard may occur more frequently than once in 5 years, or a greater than 20% chance per year.

CLIMATE CHANGE AND EXTREME TEMPERATURES

Extreme cold events are predicted to decrease in the future, while extreme heat days, as well as average temperatures are projected to increase (Figure 19). Average temperatures in Massachusetts are projected to increase by 3.8 to 10.8 degrees by the end of the century (SHMCAP). Over time our climate will become more similar to areas south of New England such as Virginia or North Carolina.

Figure 19: Massachusetts Projected Temperatures for Climate Scenarios to 2100



Source: ResilientMA.org

Future temperature projections for the nearby City of Somerville, based on the Cambridge Climate Change Vulnerability Assessment, estimate that annual average temperatures will increase by 2-3°F by 2030, and could increase by as much as 7-8°F (under the high emissions scenario) by 2070 (Table 19). By the end of the century, average summer temperatures are expected to experience proportionally greater temperature increases than winter temperatures.

Table 19: Projected Temperatures for Climate Scenarios to 2070

	1971-2000 Average	2030 RCP4.5	2030 RCP8.5	2070 RCP4.5	2070 RCP8.5
Average Annual Temperature	50.0	53.0	53.5	55.8	58.7
Average Summer Temperature	70.6	74.5	74.8	77.4	80.6
Average Winter Temperature	29.8	32.2	33.0	34.6	38.0

Source: Somerville Climate Change Vulnerability Assessment

Extreme heat days are also projected to increase; by 2030, it is anticipated that the region could experience as many as 29-40 days over 90°F and, by 2070, that number could increase to 47-90 days over 90°F. By 2070, it is possible that the entire summer will be marked by temperatures above 90°F. (Figure 20). Some of the risks associated with extreme heat are illustrated in Figure 21.

Figure 20: Comparison of Days Above 90F for Low and High Emission Scenarios

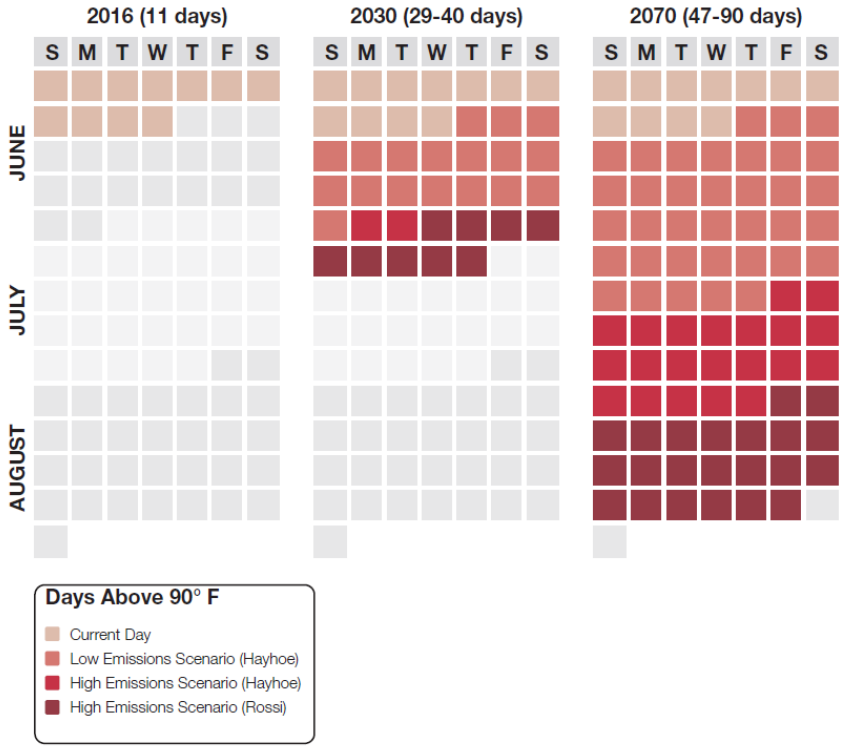


Figure 21 Health Risks Associated with Extreme Heat

Source: Killer Heat in the United States, Union of Concerned Scientists

WILDFIRE HAZARDS

A wildfire is a non-structure fire occurring in a forested, shrub or grassland area. In the Boston region these fires rarely grow to the size of a wildfire, as seen more typically in the western U.S or even more rural areas of Massachusetts. A more likely occurrence is brush fires that typically burn no more than the underbrush of a forested area or an area of Phragmites. There are three different classes of wildfires:

- Surface fires burn along the floor of a forest, moving slowly and killing or damaging trees.
- Ground fires are usually started by lightning and burn on or below the forest floor.
- Crown fires spread rapidly by wind, jumping along the tops of trees.

A wildfire differs greatly from other fires by its extensive size, the speed at which it can spread out from its original source, its potential to unexpectedly change direction, and its ability to jump gaps such as roads, rivers, and fire breaks. Wildfire season can begin in March and usually ends in late November. The majority of wildfires typically occur in April and May, when the majority of vegetation is void of any appreciable moisture, making them highly flammable. Once "green-up" takes place in late May to early June, the fire danger usually is reduced somewhat.

Fires can present a hazard where there is the potential to spread into developed or inhabited areas, particularly residential areas where sufficient fuel materials might exist to allow the fire the spread into homes. Protecting structures from fire poses special problems and can stretch firefighting resources to the limit. If heavy rains follow a fire, other natural disasters can occur, including landslides, mudflows, and floods. If **a** wildfire destroys the ground cover, then erosion becomes one of several potential problems. Should a wildfire occur in Chelsea or in other nearby communities, the resulting smoke could have negative impacts on air quality. This could have public health impacts, particularly for those with respiratory conditions such as asthma.

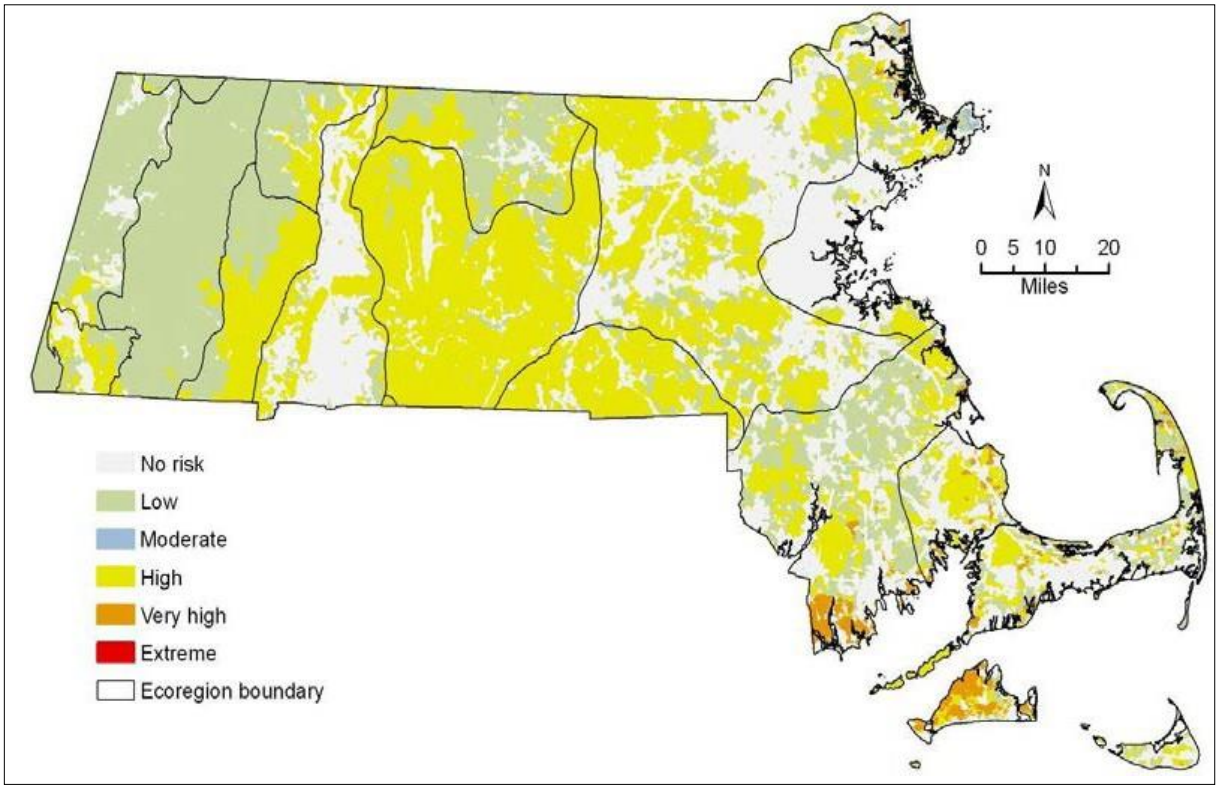
Potential Wildfire Hazard Areas

The SCHMCAP depicts statewide fire risk incorporating three risk components: fuel, wildland-urban interface, and topography (Figure 22). The wildland-urban interface reflects communities where housing and vegetation intermingle, and fire can spread from structures to vegetated areas. The most susceptible fuels are pitch pine, scrub oak and oak forests. Topography can affect the behavior of fires, as fire spreads more easily uphill. Chelsea is shown in the no risk zone.

Although infrequent, the City considers brushfires to be a hazard of concern. No outdoor burning is permitted in Chelsea. The most common cause of brushfires has been vandalism igniting Spartina marsh grasses and Phragmites. The following areas were identified by the City as having the highest potential for brush fires. The numbers correspond to the numbers on Map 8, "Hazard Areas":

5. Mill Creek area- phragmites
6. Island End Road area- phragmites
7. Locke Street area- phragmites
8. Prattville- phragmites near housing project
9. Library and Willow Street area
10. Northeastern Fuel Tank site area- phragmites
11. Mill Creek Condo area- open area with brush

Figure 22: Wildfire Risk Areas in Massachusetts



Source: SHMCAP

Potential vulnerabilities to brushfire include damage to structures and other improvements, injuries and loss of life, and impacts on natural resources. Smoke and air pollution from wildfires can be a health hazard, especially for sensitive populations including children, the elderly, and those with respiratory and cardiovascular diseases. Wildfire may also threaten the health and safety of those fighting the fires. First responders are exposed to the dangers from the initial incident and after-effects from smoke inhalation and heat stroke. However, in Chelsea, the extent and frequency of brushfires is low, and the City has not experienced serious impacts.

Based on past occurrences, brushfires in Chelsea are of Medium frequency, events that can occur from once in 5 years to once in 50 years (2% to 20% probability per year).

EXTREME WEATHER

HURRICANES AND TROPICAL STORMS

A hurricane is a violent wind and rainstorm with wind speeds of 74 to 200 miles per hour. A hurricane is strongest as it travels over the ocean and is particularly destructive to coastal property as the storm hits land. A tropical storm has similar characteristics, but wind speeds are between 34 and 73 miles per hour. Climate models suggest that hurricanes and tropical storms will become more intense as warmer ocean waters provide more fuel for the storms. In addition, rainfall amounts associated with

hurricanes are predicted to increase because warmer air can hold more water vapor. Hurricanes are seasonal events that occur between June and November.

Hurricane intensity is measured according to the Saffir/Simpson scale, which categorizes hurricane intensity linearly based upon maximum sustained winds, barometric pressure, and storm surge potential. These are combined to estimate potential damage. Table 20 gives an overview of the wind speeds, surges, and range of damage caused by different hurricane categories:

Table 20: Saffir/Simpson Scale

Scale No. (Category)	Winds (mph)	Surge (ft)	Potential Damage
1	74 – 95	4 - 5	Minimal
2	96 – 110	6 - 8	Moderate
3	111 – 130	9 - 12	Extensive
4	131 – 155	13 - 18	Extreme
5	> 155	>18	Catastrophic

Source: NOAA

Previous Occurrences

The region has been impacted by hurricanes throughout its history, starting with the Great Colonial Hurricane of 1635. Since 1900, 39 tropical storms have impacted New England (NESEC), and Massachusetts has experienced approximately 32 tropical storms, nine Category 1 hurricanes, five Category 2 hurricanes and one Category 3 hurricane. Hurricanes in Massachusetts since 1938 are shown in Table 21.

As shown on Map 5 in Appendix A, no hurricanes have tracked directly through Chelsea. A hurricane storm track is the line that delineates the path of the eye of a hurricane or tropical storm. However tropical storms and hurricanes have regional impacts, and Chelsea can experience the impacts of the wind and rain from hurricanes and tropical storms regardless of whether a storm track passes directly through the city. The hazard mapping indicates that the 100-year wind speed in Chelsea is 110 miles per hour.

Falling trees and branches are a significant impact of the high winds of hurricanes, which often results in power outages or block traffic and emergency routes when they fall on roads. Rainfall associated with hurricanes can cause flooding In the city's rivers and streams, as well as localized urban drainage flooding. Potential hurricane damages to Chelsea have been estimated using HAZUS-MH. Total damages are estimated at $24.5 million for a 100-year frequency hurricane and $113.9 million for a 500-year hurricane. Table 37 summarizes other impacts such as storm debris and evacuation needs of hurricanes.

Hurricanes are a city-wide hazard in Chelsea.

Table 21: Hurricane Records for Massachusetts 1938-2018

Hurricane Event	Date
Great New England Hurricane	September 21, 1938
Great Atlantic Hurricane	September 14-15, 1944
Hurricane Doug	September 11-12, 1950
Hurricane Carol	August 31, 1954
Hurricane Edna	September 11, 1954
Hurricane Diane	August 17-19, 1955
Hurricane Donna	September 12, 1960
Hurricane Gloria	September 27, 1985
Hurricane Bob	August 19, 1991
Hurricane Earl	September 4, 2010
Tropical Storm Irene	August 28, 2011
Hurricane Sandy	October 29-30, 2012

Source: National Oceanic and Atmospheric Administration

Based on records of previous occurrences, hurricanes in Chelsea are a medium frequency event. This hazard occurs from once in 5 years to once in 50 years, or a 2% to 20% chance per year.

SEVERE WINTER STORM/NOR'EASTER

Nor'easters

A northeast storm, known as a nor'easter, is typically a large counterclockwise wind circulation around a low-pressure center. Featuring strong northeasterly winds blowing in from the ocean over coastal areas, nor'easters are relatively common in the winter months in New England occurring one to two times a year. The storm radius of a nor'easter can be as much as 1,000 miles (see Figure 23) and these storms feature sustained winds of 10 to 40 mph with gusts of up to 70 mph. These storms are accompanied by heavy rain or snow, depending on temperatures.

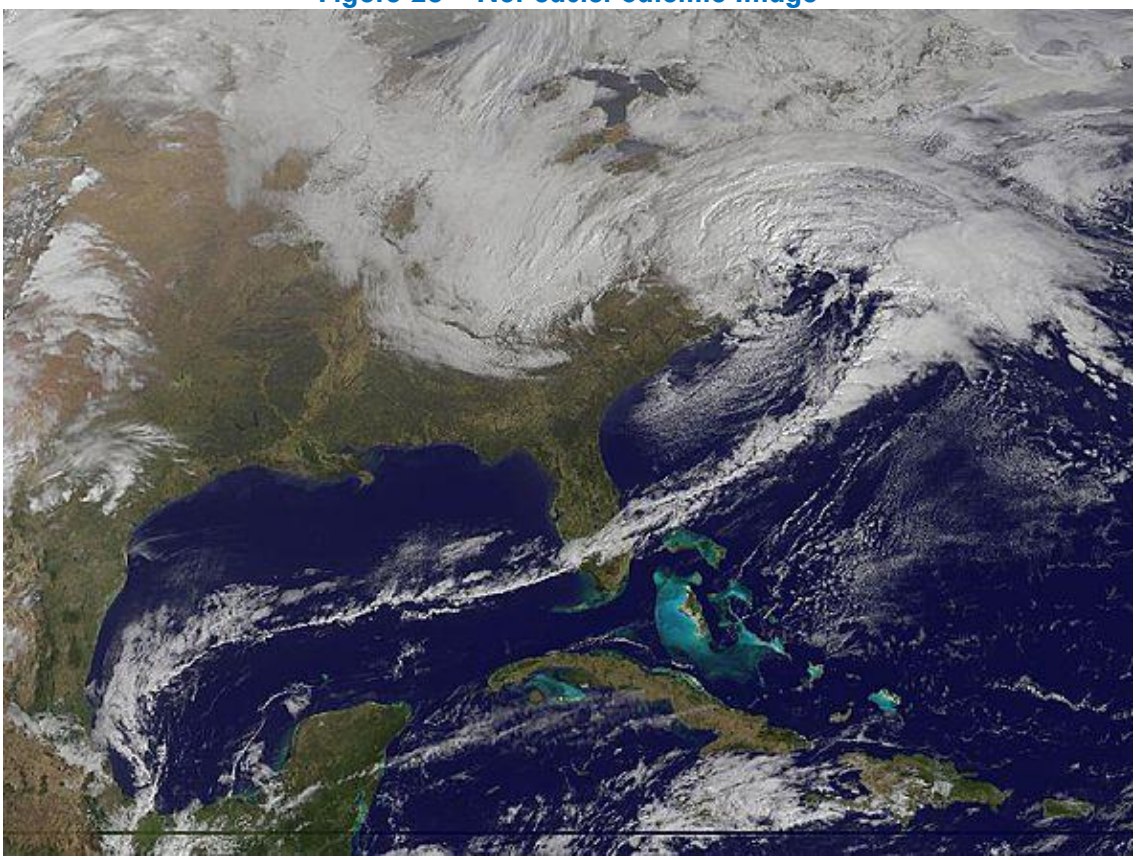
Previous Nor'easter Occurrences

Previous occurrences of nor'easters include the storm events shown on Table 22. Many of the historic flood events identified in the previous section were precipitated by nor'easters, including the "Perfect Storm" event in 1991. More recently, blizzards in February 2013, January 2015, and in March 2018 were large nor'easters that caused significant snowfall amounts.

Table 22: Nor'easter Events for Massachusetts, 1978 to 2021

Date	Nor'easter Event
February 1978	Blizzard of 1978
October 1991	Severe Coastal Storm ("Perfect Storm")
December 1992	Great Nor'easter of 1992
January 2005	Blizzard/Nor'easter
October 2005	Coastal Storm/Nor'easter
April 2007	Severe Storms, Inland & Coastal Flooding
January 2011	Winter Storm/Nor'easter
October 2011	Severe Storm/Nor'easter
February 2013	Blizzard of 2013
January 2015	Blizzard of 2015
March 2015	March 2015 Nor'easter
January 2018	Nor'easter
March 2018	Nor'easter

Figure 23 – Nor'easter Satellite Image



Source: The Geostationary Operational Environmental Satellite Program (GOES), A joint effort of NASA and NOAA..

Chelsea is vulnerable to both the wind and precipitation that accompany nor'easters. High winds can cause damage to structures, fallen trees, and downed power lines leading to power outages. Intense rainfall can overwhelm drainage systems causing localized flooding of rivers and streams as well as urban stormwater ponding and localized flooding. Fallen tree limbs as well as heavy snow accumulation and intense rainfall can impede local transportation corridors, and block access for emergency vehicles. The entire City of Chelsea is potentially at risk to the impacts of nor'easters.

Based on previous occurrences, nor'easters in Chelsea are high frequency events. This hazard may occur more frequently than once in five years (greater than 20% chance per year).

BLIZZARDS AND HEAVY SNOW

Winter storms, including heavy snow, blizzards, and ice storms, are the most common and most familiar of the region's hazards that affect large geographic areas. Winter storms are a combination hazard because they often involve wind, ice, and heavy snow fall. The National Weather Service defines "heavy snow fall" as an event generating at least four inches of snowfall within a 12-hour period. Blizzards and winter storms are often associated with a nor'easter event, a large counterclockwise wind circulation around a low-pressure center often resulting in heavy snow, high winds, and rain (see nor'easters above).

A blizzard is a winter snowstorm with sustained or frequent wind gusts to 35 mph or more, accompanied by falling or blowing snow which reduces visibility to or below ¼ mile. These conditions must be the predominant condition over a three-hour period. Extremely cold temperatures are often associated with blizzard conditions but are not a formal part of the definition. The hazard related to the combination of snow, wind, and low visibility significantly increases when temperatures drop below 20 degrees.

The Regional Snowfall Index (RSI) characterizes and ranks the severity of northeast snowstorms. RSI has five categories: Extreme, Crippling, Major, Significant, and Notable. RSI scores are a function of the area affected by the storm, the amount of snow, and the number of people living in the path of the storm. The largest RSI values result from storms producing heavy snowfall over large areas that include major metropolitan centers. The RSI categories are shown in Table 23.

Table 23: Regional Snowfall Index

Category	RSI	Value
1	1 – 3	Notable
2	3-6	Significant
3	6-10	Major
4	10-18	Crippling
5	18+	Extreme

Source: SHMCAP, 2018

The most significant winter storm in recent history was the "Blizzard of 1978," which resulted in over three feet of snowfall and multiple day closures of roadways, businesses, and schools. Table 24 shows the blizzards and severe winter storms that were declared disasters since 1966:

Table 24: Severe Winter Storm Disaster Declarations in Eastern MA

Storm Event	Date
Severe Winter Storm and Snowstorm	March 2018
Severe Winter Storm, Snowstorm, Flooding	January 2015
Severe Winter Storm, Snowstorm, Flooding	February 2013
Severe Storm and Snowstorm	October 2011
Severe Winter Storm and Snowstorm	January 2011
Severe Winter Storm and Flooding	December 2008
Blizzard	December 1992
Winter Coastal Storm	October 1991
Blizzard of 1978	February 1978
Coastal Storm, Flood, Ice, Snow	January 1966

Source: FEMA

The best available local data on past occurrences and impacts of winter storm events are reported for Suffolk County by the National Centers for Environmental Information (NCEI). From 2010 through 2020, Suffolk County experienced 43 winter storm events, including three blizzards, resulting in one injury, no deaths, and $701,000 in property damage, as shown in Table 25.

Table 25: Winter Storms, Heavy Snow and Blizzards in Suffolk County, 2010 through 2021

Date	Event	Deaths	Injuries	Property Damage ($)
12/26/2010	Winter Storm	0	0	0
1/12/2011	Winter Storm	0	0	50000
1/21/2011	Winter Storm	0	0	0
1/26/2011	Heavy Snow	0	0	0
2/1/2011	Winter Storm	0	0	432000
1/21/2012	Winter Storm	0	0	0
2/8/2013	Heavy Snow	0	0	0
2/8/2013	Blizzard	0	0	0
2/17/2013	Winter Storm	0	0	0
3/7/2013	Heavy Snow	0	0	0
3/18/2013	Heavy Snow	0	0	0
12/17/2013	Heavy Snow	0	0	0
1/2/2014	Heavy Snow	0	0	0

2/5/2014	Heavy Snow	0	0	0
1/24/2015	Heavy Snow	0	0	0
1/26/2015	Blizzard	0	0	0
2/2/2015	Heavy Snow	0	0	0
2/8/2015	Heavy Snow	0	0	0
2/14/2015	Heavy Snow	0	0	0
1/23/2016	Heavy Snow	0	0	0
2/5/2016	Heavy Snow	0	0	10000
2/8/2016	Heavy Snow	0	0	0
3/21/2016	Winter Storm	0	0	0
4/4/2016	Winter Storm	0	0	0
12/17/2016	Winter Storm	0	0	0
1/7/2017	Winter Storm	0	0	0
2/8/2017	Winter Storm	0	0	150000
2/9/2017	Winter Storm	0	0	0
3/14/2017	Heavy Snow	0	0	0
12/9/2017	Winter Storm	0	0	0
12/22/2017	Winter Storm	0	1	5000
12/25/2017	Winter Storm	0	0	2000
1/4/2018	Winter Storm	0	0	0
2/7/2018	Winter Storm	0	0	40000
2/17/2018	Winter Storm	0	0	0
3/7/2018	Winter Storm	0	0	0
3/13/2018	Blizzard	0	0	10000
1/19/2019	Winter Storm	0	0	0
2/18/2019	Winter Storm	0	0	0
3/3/2019	Winter Storm	0	0	0
10/30/2020	Winter Storm	0	0	2000
12/16/2020	Heavy Snow	0	0	0
2/7/2021	Heavy Snow	0	0	0
TOTAL		**0**	**1**	**$701,000**

Source: NOAA, National Centers for Environmental Information

The majority of blizzards and winter storms in the region cause more inconvenience than they do serious property damage, injuries, or deaths. However, periodically, a larger storm will occur which is a true disaster and necessitates large-scale emergency response. The impacts of winter storms are often related to the weight of snow and ice, which can cause roof collapses and also causes tree limbs to fall. This in turn can cause property damage and potential injuries. Power outages may also result from fallen trees and utility lines.

A number of public safety issues can arise during snowstorms. Impassible streets are a challenge for emergency vehicles and affect residents and employers. Snow-covered sidewalks force people to walk in streets, which are already less safe due to snow, slush, puddles, and ice. Large piles of snow can also block sight lines for drivers, particularly at intersections. Refreezing of melting snow can cause dangerous roadway conditions. In addition, transit operations may be impacted, as they were in the 2015 blizzards which caused the closure of the MBTA system for one day and limited services on the commuter rail for several weeks.

During winter storms, there can be an increased risk of fire due to loss of electricity and the associated use of portable heaters, gas stoves, candles, and other flammable sources of heat and light. Fire during winter storms presents a potential danger because water supplies may freeze, and it may be difficult for firefighting apparatus to get to a fire.

Other vulnerabilities include catch basins being buried and sometimes clogged, water service pipes bursting, and shut-off valves being buried (more common when cold and windy), fire hydrants being buried by snow, older water mains bursting, and dangerous icicles forming on buildings. Snow can also block building ventilation, increasing the risk of indoor carbon monoxide poisoning and cause damage to structures due to heavy snow loads and ice dams.. Automobile and other transportation accidents are the leading cause of death during winter storms with exhaustion caused by over-exertion as the second leading cause. The rapid melting of snow after major storms, combined with rainfall, is a common flooding threat.

The Chelsea DPW works to clear roads as requested by emergency service providers and carries on general snow removal operations. MA Department of Transportation removes snow from Routes 16 and 1A. The City has also reduced its use of sand, opting for more salt, which reduces clogging of storm drains and the amount of sand that must be swept from the streets in the Spring. The City bans on-street parking at nights during snow emergencies.

Blizzards and heavy snow are a potential city-wide hazard in Chelsea. Map 6 in Appendix A indicates that the average annual average snowfall in most of Chelsea is between 48 and 72 inches.

Based on the record of previous occurrences, blizzards and heavy snow in Chelsea are high frequency events. This hazard may occur more frequently than once in 5 years, with a greater than 20 percent chance of occurring each year.

Climate Change and Nor'easters/Winter Storms

As with hurricanes, warmer ocean water and air will provide more fuel for winter storms. According to the SHMCAP it appears that Atlantic coast nor'easters are increasing in frequency and intensity. Further, the SHMCAP notes that research suggests that warmer weather in the Artic is producing changes to atmospheric circulation patterns that favor the development of winter storms in the Eastern United States.

ICE STORMS

The ice storm category covers a range of different weather phenomena that collectively involve rain or snow being converted to ice in the lower atmosphere leading to potentially hazardous conditions on the ground. Ice storm conditions are defined by liquid rain falling and freezing on contact with cold objects, creating ice buildups of one-fourth of an inch or more. An ice storm warning, which is now included in the criteria for a winter storm warning, is issued when a half inch or more of accretion of freezing rain is expected.

Sleet and hail are other forms of frozen precipitation. Sleet occurs when raindrops fall into subfreezing air thick enough that the raindrops refreeze into ice before hitting the ground. The difference between sleet and hail is that sleet is a wintertime phenomenon whereas hail falls from convective clouds (usually thunderstorms), often during the warm spring and summer months (see a description of hail in the Other Severe Weather section below)

The best available local data on previous ice storm events are recorded for Suffolk County through the National Centers for Environmental Information (NCEI).. NCEI records do not include any Ice Storm events for Suffolk County 2000 through 2021. The City's location in the milder coastal region makes it less vulnerable to ice storms than adjacent inland areas such as Middlesex and Essex Counties. Should an ice storm occur in Chelsea, the greatest hazard is created by freezing rain conditions, which is rain that freezes on contact with hard surfaces leading to a layer of ice on roads, walkways, trees, and other surfaces. The conditions created by freezing rain can make driving particularly dangerous and emergency response more difficult. The weight of ice on tree branches can also lead to falling branches causing power outages and blocking roadways. The impacts of winter storms may also include roof collapses and property damage and injuries related to the weight of snow and ice.

Based on past occurrences, Ice storms are considered low frequency event in Chelsea. This hazard may occur once in every 50 to 100 years, with a 1% to 2% chance of occurring each year. There is some indication that as winters warm, temperatures may be more likely to produce icing conditions.

TORNADOES

A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud. These events are spawned by thunderstorms and occasionally by hurricanes and may occur singularly or in multiples. They develop when cool air overrides a layer of warm air, causing the warm air to rise rapidly. Most vortices remain suspended in the atmosphere. Should they touch down, they become a force of destruction. Some ingredients for tornado formation include:

- Very strong winds in the mid and upper levels of the atmosphere
- Clockwise turning of the wind with height (from southeast at the surface to west aloft)
- Increasing wind speed with altitude in the lowest 10,000 feet of the atmosphere (i.e., 20 mph at the surface and 50 mph at 7,000 feet)
- Very warm, moist air near the ground with unusually cooler air aloft
- A forcing mechanism such as a cold front or leftover weather boundary from previous shower or thunderstorm activity
- Tornados are most common in the summer, June through August, and most form in the afternoon or evening. Tornados can also be associated with strong thunderstorms.

Tornado damage severity is measured by the Enhanced Fujita scale, which is based on the amount of damage created (Figure 23). As of February 1, 2007, the National Weather Service began rating tornados using the Enhanced Fujita-scale (EF-scale), which allows surveyors to create more precise assessments of tornado severity. The EF-scale is summarized in Figure 24.

The frequency of tornadoes in eastern Massachusetts is low; on average, there are six tornadoes that touchdown somewhere in the Northeast region every year. According to NOAA's Severe Weather Database, since 1950 there have been 177 tornadoes in Massachusetts, 111 of these occurred in central and western parts of the state. Four of these were F4 tornadoes, six were F3, 36 were F3, and 91 were F1. There was only one tornado recorded in Suffolk County, described below.

The strongest tornado in Massachusetts history was the Worcester Tornado in 1953 (NESEC). This F4 tornado was 35 miles long and resulted in 94 deaths and 1245 injuries. A more recent significant tornado event in Massachusetts occurred in 2011; an EF3 tornado touched down in Springfield tracked for 35 miles through six communities. The tornado outbreak included 7 confirmed tornadoes with a maximum rating of EF3 and lasted for 3 hours and 42 minutes as they swept through eight communities across western and central Massachusetts. The town of Monson was hit particularly hard. More than 230 buildings were damaged in Monson with a third classified as total losses. These tornadoes also resulted three deaths, 200 injuries, and $227 million in damages.

Figure 24: Enhance Fujita Scale

Scale	Wind speed		Relative frequency	Potential damage	
	mph	km/h			
EF0	65–85	105–137	53.5%	Minor damage. Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over. Confirmed tornadoes with no reported damage (i.e., those that remain in open fields) are always rated EF0.	
EF1	86–110	138–178	31.6%	Moderate damage. Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.	
EF2	111–135	179–218	10.7%	Considerable damage. Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.	
EF3	136–165	219–266	3.4%	Severe damage. Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.	
EF4	166–200	267–322	0.7%	Extreme damage to near-total destruction. Well-constructed houses and whole frame houses completely leveled; cars thrown and small missiles generated.	
EF5	>200	>322	<0.1%	Massive Damage. Strong frame houses leveled off foundations and swept away; steel-reinforced concrete structures critically damaged; high-rise buildings have severe structural deformation. Incredible phenomena will occur.	

Source: SHMCAP 2018

The best available local data on past occurrences and impacts of tornadoes are reported for Suffolk County by the National Centers for Environmental Information (NCEI). Only one tornado has occurred in Suffolk county (Table 26), which touched down in Chelsea and Revere, as described below.

Table 26 Tornado Records for Suffolk County

Date	Fujita	Fatalities	Injuries	Damage
70/28/2014	EF2	0	2	$4,000,000

Source: NOAA, National Centers for Environmental Information

An EF2 tornado struck part of Chelsea and the neighboring City of Revere on July 28, 2014. The tornado touched down at 9:32 AM in Chelsea just south of Route 16 (Revere Beach Parkway), where a window was blown out on Dudley Street. However, the overwhelming majority of damage occurred in Revere. After touching down in Chelsea, the tornado moved north into Revere's business district along Broadway, past Revere City Hall, and ended at 9:36 AM near the intersection of Routes 1 and 60 (see Figure 24). The path was approximately two miles long and 3/8 mile wide, with wind speeds up to 120 miles per hour.

Figure 24 – Path of Everett-Revere Tornado, July 28, 2014

Source: Boston Globe

Most of the damage was rated EF-1, but EF-2 rated damage did occur near Revere Beach Parkway. Windows were blown out of Revere City Hall and the roof was damaged. Sixty-four structures sustained damage that ranged from siding torn off to roofs lifted or blown off. Thirteen of these structures (6 - 1 & 2 family homes, 3 - multifamily homes, and 4 commercial buildings) were deemed uninhabitable.. Trees fell on cars, a few of these crushed. Revere High School also sustained damage.

Police reported a car that had been overturned at the intersection of Revere Street and Carleton Avenue. Near the rotary at Route 60 and Broadway, a billboard was blown onto several cars. The city set up a shelter at a local school for displaced residents. National Grid reported that 3,000 homes were without power.

Another recent eastern Massachusetts tornado struck the Town of Concord. On August 22, 2016, an EF1 tornado passed through part of the Town of Concord. It impacted an area 0.85 miles long by 400 yards wide. According to the report from the National Centers for Environmental Information:

> "This tornado touched down near the Cambridge Turnpike (Route 2) and headed northeast. Numerous trees were uprooted or had the tops sheared off. These subsequently blocked roads, damaged homes, and downed power lines, cutting off power to the neighborhood. Thirty-nine houses in this area were damaged. Only one house suffered significant structural damage. The historical home of Louisa May Alcott and her family was right next to the tornado path but was not damaged."

Although tornadoes are a potential city-wide hazard in Chelsea, tornado impacts are relatively localized compared to widespread damages related to severe storms and hurricanes. Depending on the track of a tornado in Chelsea, damages could be high due to the prevalence of older construction that pre-dates the current building code, as well as the density of development. Chelsea was fortunate that the 2014 tornado did not strike a densely developed area, but neighboring Revere was not so luck, and provides an example of the greater damages that are possible. Evacuation of impacted areas may be required on short notice. As was the case in Revere, sheltering efforts may be required along with debris clearance. In severe events, search and rescue, and other emergency fire and medical services may need to be deployed. Key routes may be blocked by downed trees and debris, and widespread power outages are also typically associated with tornadoes.

Based on the record of previous occurrences, tornadoes in Chelsea are a low frequency event. This hazard may occur once in 50 to100 years, with a 1% to 2% probability per year.

OTHER SEVERE WEATHER

SEVERE THUNDERSTORMS

While less severe than the other types of storms discussed, thunderstorms can lead to localized damage and represent a hazard risk for communities. A thunderstorm typically features lightning, strong winds, rain, and/or hail. Thunderstorms sometime give rise to tornados. On average, these storms are only around 15 miles in diameter and last for about 30 minutes. A severe thunderstorm can include winds of close to 60 mph and rain sufficient to produce flooding. The severity of thunderstorms ranges from commonplace and of short duration to intense storms that cause damage due to high winds, flooding, or lightning strikes.

The best available data on previous occurrences of thunderstorms in Chelsea is for are recorded for Suffolk County through the National Centers for Environmental Information (NCEI). For the years 2010 through 2021, NCDC records show 29 thunderstorm events in Suffolk County (Table 27). These storms resulted in a total of $658,900in property damage. There were no injuries or deaths reported.

Table 27: Suffolk County Thunderstorm Events, 2010 through 2021

Date	Max. Wind Speed (mph)	Deaths	Injuries	Property Damage
6/1/2010	50	0	0	10000
6/3/2010	50	0	0	500
6/6/2010	50	0	0	145000
6/24/2010	50	0	0	15000
6/1/2011	50	0	0	20000
8/19/2011	50	0	0	15000
6/8/2012	50	0	0	30000
9/8/2012	50	0	0	5000
7/3/2014	50	0	0	15000
8/4/2015	50	0	0	50000
2/25/2016	60	0	0	20000
6/29/2016	50	0	0	15000
7/18/2016	50	0	0	70000
7/23/2016	50	0	0	83000
6/27/2017	50	0	0	1000
7/12/2017	50	0	0	1000
8/2/2017	50	0	0	1000
9/14/2017	57	0	0	25000
7/17/2018	45	0	0	1300
7/31/2019	65	0	0	39500
8/7/2019	50	0	0	300
5/15/2020	50	0	0	3500
6/28/2020	50	0	0	1800
7/23/2020	50	0	0	800
10/7/2020	57	0	0	0
6/29/2021	50	0	0	500
6/30/2021	50	0	0	1800
7/7/2021	55	0	0	1000
7/27/2021	61	0	0	86900
TOTAL		**0**	**0**	**$658,900**

Source: NOAA, National Centers for Environmental Information

Severe thunderstorms are a city-wide hazard for Chelsea. The city's vulnerability to severe thunderstorms is similar to that of nor'easters. High winds can cause falling trees and power outages, as well as obstruction of key routes and emergency access. Heavy precipitation may also cause localized flooding, both riverine and urban drainage related.

Based on the record of previous occurrences, thunderstorms in Chelsea are high frequency events occurring more frequently than once in 5 years, or a greater than 20% per year.

As noted previously, the intensity of rainfall events has increased significantly, and those trends are expected to continue. The SHMCAP does not specifically address whether climate will affect the intensity or frequency of thunderstorms.

HAIL

Hail events are frequently associated with thunderstorms and other severe storm events. Hail size typically refers to the diameter of the hailstones. Warnings and reports may report hail size through comparisons with real-world objects that correspond to certain diameters as shown in Table 28:

Table 28: Hail Size Comparisons

Description	Diameter (inches)
Pea	0.25
Marble or mothball	0.50
Penny or dime	0.75
Nickel	0.88
Quarter	1.00
Half dollar	1.25
Walnut or ping pong ball	1.50
Golf ball	1.75
Hen's egg	2.00
Tennis ball	2.50
Baseball	2.75
Teacup	3.00
Grapefruit	4.00
Softball	4.50

Source: NOAA

The best available local data on previous hail events are recorded for Suffolk County through the National Centers for Environmental Information (NCEI). There were 14 hail events recorded from 2010 through 2021, as shown in Table 29. There was no property damages and no injuries or deaths reported for any of these hail events. Potential damages from larger-size hail could include damage to vehicles, windows, and other structures. These damages have not been reported in Chelsea.

Table 29: Suffolk County Hail Events, 2010 through 2021

Date	Magnitude	Deaths	Injuries	Property Damage
5/8/2010	1	0	0	0
6/5/2010	0.75	0	0	0
8/19/2011	0.75	0	0	0
8/19/2011	1	0	0	0
6/8/2012	0.75	0	0	0
7/18/2012	1.25	0	0	0
7/18/2012	0.75	0	0	0
6/17/2013	0.75	0	0	0
8/4/2015	1.5	0	0	0
8/4/2015	2	0	0	0
7/23/2016	0.75	0	0	0
6/13/2017	0.75	0	0	0
6/28/2020	0.75	0	0	0
8/23/2020	0.75	0	0	0
TOTAL		**0**	**0**	**0**

Source: NOAA, National Centers for Environmental Information
*Magnitude refers to diameter of hail stones in inches

Hail events are a potential city-wide hazard in Chelsea. Based on the record of previous occurrences, hail events in Chelsea are high frequency events occurring more frequently than once in 5 years, or a greater than 20% per year.

NON-CLIMATE INFLUENCED HAZARDS

EARTHQUAKES

Earthquakes are the sole natural hazard for which there is no established correlation with climate impacts. Damage in an earthquake stems from ground motion, surface faulting, and ground failure in which weak or unstable soils, such as those composed primarily of saturated sand or silts, liquefy. The effects of an earthquake are mitigated by distance and ground materials between the epicenter and a given location. An earthquake in New England affects a much wider area than a similar earthquake in California due to New England's solid bedrock geology (NESEC).

Seismologists use a magnitude scale known as the Richter scale to express the seismic energy released by each earthquake. The typical effects of earthquakes in various ranges are summarized in Table 30.

Table 30: Richter Scale and Effects

Richter Magnitudes	Earthquake Effects
Less than 3.5	Generally, not felt, but recorded
3.5- 5.4	Often felt, but rarely causes damage
Under 6.0	At most slight damage to well-designed buildings. Can cause major damage to poorly constructed buildings over small regions.
6.1-6.9	Can be destructive in areas up to about 100 km. across where people live.
7.0- 7.9	Major earthquake. Can cause serious damage over larger areas.
8 or greater	Great earthquake. Can cause serious damage in areas several hundred meters across.

Source: Nevada Seismological Library (NSL), 2005

From 1668 to 2016, 408 earthquakes were recorded in Massachusetts (NESEC). Most have originated from the La Malbaie fault in Quebec or from the Cape Anne fault located off the coast of Rockport. The region has experienced larger earthquakes in the distant past, including a magnitude 5.0 earthquake in 1727 and a 6.0 earthquake that struck in 1755 off the coast of Cape Anne. More recently, a pair of damaging earthquakes occurred near Ossipee, NH in 1940. A 4.0 earthquake centered in Hollis, Maine in October 2012 was felt in the Boston area. Historic records of some of the more significant earthquakes in the region are shown in Table 31.

Table 31: Historic Earthquakes in Massachusetts or Surrounding Area

Location	Date	Magnitude
MA - Cape Ann	11/10/1727	5
MA - Cape Ann	12/29/1727	NA
MA - Cape Ann	2/10/1728	NA
MA - Cape Ann	3/30/1729	NA
MA - Cape Ann	12/9/1729	NA
MA - Cape Ann	2/20/1730	NA
MA - Cape Ann	3/9/1730	NA
MA – Boston	6/24/1741	NA
MA - Cape Ann	6/14/1744	4.7
MA – Salem	7/1/1744	NA
MA - Off Cape Ann	11/18/1755	6
MA - Off Cape Cod	11/23/1755	NA
MA – Boston	3/12/1761	4.6
MA - Off Cape Cod	2/2/1766	NA

Location	Date	Magnitude
MA – Offshore	1/2/1785	5.4
MA - Wareham/ Taunton	12/25/1800	NA
MA – Woburn	10/5/1817	4.3
MA - Marblehead	8/25/1846	4.3
MA – Brewster	8/8/1847	4.2
MA – Boxford	5/12/1880	NA
MA – Newbury	11/7/1907	NA
MA - Wareham	4/25/1924	NA
MA - Cape Ann	1/7/1925	4
MA - Nantucket	10/25/1965	NA
MA – Boston	12/27/74	2.3
MA - Nantucket	4/12/12	4.5
ME – Hollis	10/17/12	4.0

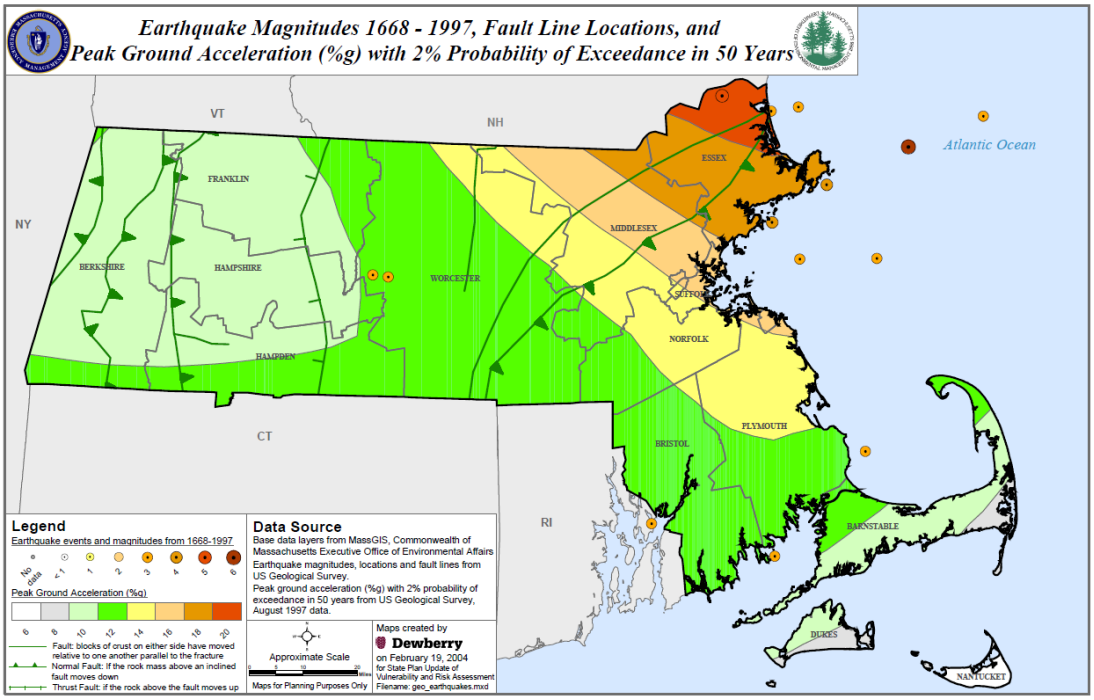
Source: Boston HIRA

One measure of earthquake risk is ground motion, which is measured as maximum peak horizontal acceleration, expressed as a percentage of gravity (%g). The range of peak ground acceleration in Massachusetts is from 10 %g to 20 %g, with a 2% probability of exceedance in 50 years, as shown in Figure 25. Chelsea is in the 16 %g to 18 %g range, making it a moderate area of earthquake risk relative to the state, although the Massachusetts as a whole is considered to have a low risk of earthquakes compared to the rest of the country. There have been no recorded earthquake epicenters within Chelsea.

Although New England has not experienced a damaging earthquake since 1755, seismologists state that a serious earthquake occurrence is possible. There are five seismological faults in Massachusetts, but there is no discernible pattern of previous earthquakes along these fault lines. Earthquakes occur without warning and may be followed by aftershocks. The majority of older buildings and infrastructure were constructed without specific earthquake resistant design features.

Earthquakes are a hazard with multiple impacts beyond the obvious building collapse. Buildings may suffer structural damage which may or may not be readily apparent. Earthquakes can cause major damage to roadways, making emergency response difficult. Water lines and gas lines can break, causing flooding and fires. Another potential vulnerability is equipment within structures. For example, a hospital may be structurally engineered to withstand an earthquake, but if the equipment inside the building is not properly secured, the operations at the hospital could be severely impacted during an earthquake. Earthquakes can also trigger landslides.

Figure 25: Massachusetts Earthquake Probability Map



Source: MA Hazard Mitigation Plan 2013

Earthquakes are a potential city-wide hazard in Chelsea. Although new construction under the most recent building codes generally is built to seismic standards, the City has several un-reinforced, older masonry buildings that would be vulnerable in a severe earthquake. All schools however, with the exception of the older Clarke Avenue School, are of modern, earthquake resistant construction. City Hall, an older brick structure, is the other primary City-owned building that would be at risk during an earthquake. Potential earthquake damages to Chelsea have been estimated using HAZUS-MH. Total building damages are estimated at $580 million for a 5.0 magnitude earthquake and $3.7 billion for a 7.0 magnitude earthquake. Other potential impacts, such as building debris and evacuation needs, estimated by HAZUS-MH are shown in Table 38.

Based on previous occurrences, earthquakes are very low frequency events in Chelsea, occurring less frequently than once in 100 years, or a less than 1% per year.

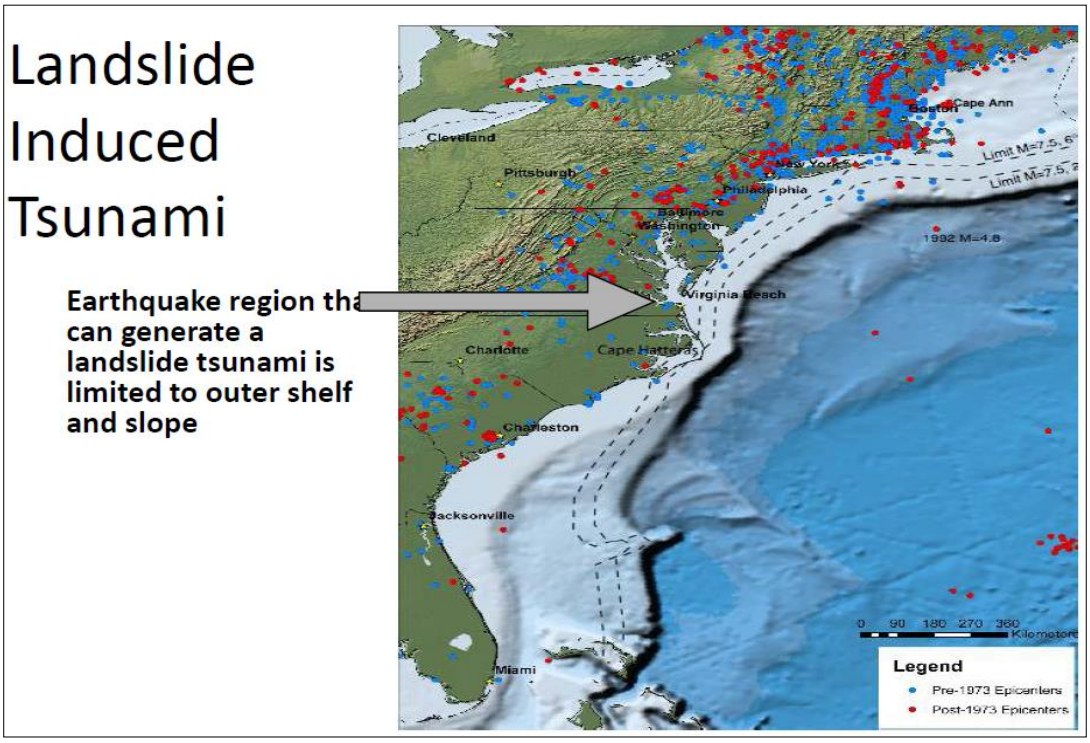
Atlantic Based Tsunami

A possible, but unlikely, earthquake-related hazard is tsunami. The Federal Emergency Management Agency defines tsunami as a series of enormous seismic sea waves created by an underwater disturbance caused by geologic activity in the form of earthquakes, volcanic eruptions, underwater landslides, or meteorites striking the Earth. A tsunami can move hundreds of miles per hour in the open ocean and smash into land with waves as high as 100 feet or more.

According to the West Coast and Alaska Tsunami Warning Center (WCATWC), an Atlantic based tsunami threat level for the US east coast is low when compared to the US Pacific and Caribbean coasts. Although the probability is low, a tsunami threat does potentially exist, and it is not out of the realm of possibility for the Atlantic. Geologists from the U.S. Geologic Survey and the Woods Hole Oceanographic Institute have researched Georges Bank Lower Slope of the North Atlantic and the relationship there between submarine landslides and earthquakes (Figure 26). "The US Atlantic coast would be particularly vulnerable to devastation from tsunami because of the high density of population and infrastructure along its low-lying coastal areas and estuaries." (Dr. Uri S ten Brink, et.al., Marine Geology 264, 2009, p.65)

Coasts that are at greater risk are areas less than 25 feet above sea level and within a mile of the shoreline. While the City of Chelsea is not located directly on the coast, it is located on the tidal Mystic River upstream from Boston Harbor, and parts of the city along the waterfront are a relatively low elevation.

Figure 26 - Atlantic Based Tsunami Potential Threat



Source:

The NOAA National Weather Service -Taunton organized a NWS-WCATWC Tsunami Awareness Emergency Manager Workshop on February 23, 2010. Since 2010, the NWS-WCATWC issued Warnings and Advisories which have not resulted in a tsunami in the Atlantic to date.

Although the City of Chelsea has never been impacted by a Tsunamis, this is a potential city-wide hazard for Chelsea. Based on past occurrences tsunamis are very low frequency events that occur less frequently than once in 100 years, or (less than 1% per year.

LAND USE

Existing Land Use

The most recent land use statistics available from the state are from aerial imagery completed in 2016. Table 32 shows the acreage and percentage of land in 16 categories. If the primary residential categories are aggregated, residential uses make up 30.4% of the area of the city, the largest land use category by area. The next largest category is Right-of-Way, which at 330 acres represents 23.3% of the total area. Commercial and industrial uses combined make up 410 acres, or 29.4% of the city. The remaining nine use categories combined make up 16.9 percent of the City, including several categories of open space, wetlands and water, forest and shrub land, and impervious land.

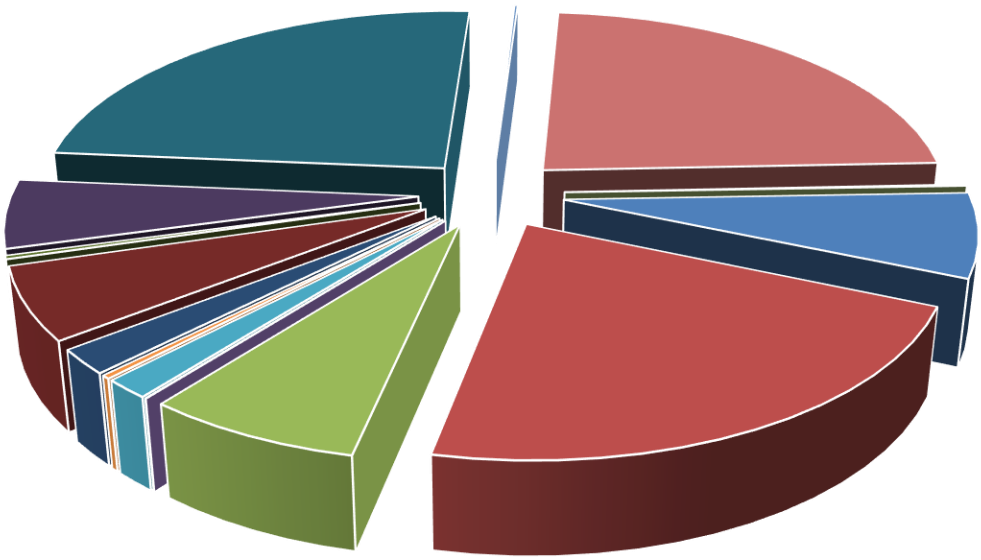
The breakdown of the 16 land use types is illustrated in Figure 27 below, and a land use map is included in Appendix A, Map 2.

Table 32: City of Chelsea Land Use

Land Use Type	Acres	Percentage
Open and Bare Land	98	6.9
Commercial	310	21.9
Industrial	103	7.3
Agriculture	0	0.0
Forest and Shrub	22	1.6
Wetlands and Shoreline	4	0.3
Developed Open Space	29	2.0
Impervious and Unknown	86	6.0
Mixed use, primarily residential	4	0.3
Residential - single family	80	5.7
Residential - multi-family	346	24.4
Mixed use, other	1	0.0
Mixed use, primarily commercial	2	0.1
Right-of-way	330	23.3
Water	1	0.1
TOTAL	**1416**	**100**

Source: MassGIS 2016 Land Use Database

Figure 27 - Chelsea Land Use 2016



- Open and Bare Land
- Commercial
- Industrial
- Agriculture
- Forest and Shrub
- Wetlands and Shoreline
- Developed Open Space
- Impervious and Unknown
- Mixed use, primarily residential
- Residential - single family
- Residential - multi-family
- Mixed use, other
- Mixed use, primarily commercial
- Right-of-way
- Water

DEVELOPMENT TRENDS

MAPC consulted with the Chelsea Planning Department to inventory recently completed developments as well as new developments that are in the planning stage or under construction. The city identified 40 development sites, 22 completed and 18 planned or under construction, shown in Table 33. These development sites were mapped and are shown on Map XX in Appendix A. The letter codes in the Map# column of Table 33 correspond to the sites shown on the map. Twenty-one of the 40 projects are residential developments, 12 are commercial, 5 are mixed use, one is a hotel, and one is a church.

Table 33 Recent and Planned New Development in Chelsea

Map#	Address	Development	Acres
COMPLETED DEVELOPMENTS			
B	85 - 87 Parker Street	Residential, 12 units	0.2
C	14 Williams/73 Winnisimmet	Restaurant & Residential	0.1
D	13 - 15 Sixth Street	Add 1 floor, 6 units	0.1
E	130 Eastern Ave	Warehouse, 103,000 square feet	7.0
F	25 Eleanor Street	20 Residential Units	0.2
G	13 - 15, 17 fifth Street	6 Completed 24 Tudor	0.1
H	87 - 89 Parker Street	Demolish 3-family, construct 12-family	0.2
I	22 Adams	Commercial	0.1
N	1001 - 1005 Broadway	38 Affordable units	0.7
O	208 Spencer Ave	8 Residential units	0.1
P	42 Blossom Street	Demo and build 4-unit, 4-floor structure	0.1
Q	235 Marginal Street	Vehicle-for-hire storage	1.3
R	35 Nichols Street	4 affordable units	0.3
S	200 (V) Maple Street	Added 80 rooms to 120-room hotel	1.3
T	121 Webster	Recreational Marijuana Dispensary	3.5
U	16 Fifth Street	Convert bar to residential use	0.0
W	157 Clark Ave	Built church in basement	0.5
X	5 - 79 Spencer Ave	Demolish 1-floor, construct 9-floor (9 unit)	0.1
Y	80 Eastern Ave	Marijuana cultivator, processor, dispensary	1.2
CC	52 Spencer Ave	Demolish 1 floor, build 4 floors	0.1
EE	932 Broadway	Vacant nursing home--office & 33 residential units	0.7
II	13 - 15 Fifth Street	Convert restaurant to 4 residences	0.1
NEW DEVELOPMENTS			
A	200 Beacham	Marijuana Retailer (under construction)	0.4
J	157 Crescent Ave	Trade shop with office (planned)	0.4
K	170 Cottage Street	66 Residential Units (planned)	1.2
L	1 Forbes Street	Mixed use, 630 (planned)	12.6

Map#	Address	Development	Acres
M	176-178 Washington Ave.	Mixed use (33), retail first floor (in construction)	0.2
V	54 Washington Ave	Add third floor with 10 new apartments (planned)	0.1
Z	201 Marginal Street	2-story office building (planned)	0.8
AA	25 Sixth Street	62 affordable units (planned)	0.7
BB	170 Central Ave	330 mixed income units in 40R zone, (planned)	2.3
DD	51 Crescent Ave	Demolish 3F, build 10F (in construction)	0.2
FF	440 Broadway	1 story building to mixed use with 2400sf retail first floor, 16 units above (planned)	0.2
GG	45 Market Street	Construct 12,008 warehouse (planned)	0.7
HH	84 - 86 Blossom Street	Demolish 2F and convert to 4F (planned)	0.1
JJ	25 Second Street	20 residential units (in construction)	0.3
KK	926 Broadway	Mixed use: First floor office, 8 units above (planned)	0.1
LL	22 Willow & 250 Marginal St.	Construct 146,410sf warehouse (planned)	8.3
MM	157 - 163 Chestnut Street	Convert church to 30 residential units (planned)	0.6
NN	25 Griffin Way	Auto prep & EV repair (planned)	1.3

Source: Chelsea Planning Department

It is notable from a hazard perspective that due to Chelsea's compact urban development pattern, most of these sites are relatively small in land area. Of the 40 sites, 30 are less than 1 acre, nine are under 10 acres, and total land area for all 40 sites is just 48.4 acres. These compact developments generally have a smaller "footprint" with respects to impacts like impervious surface and flooding.

In order to characterize the city's vulnerability associated with development, a GIS mapping analysis was conducted which overlaid the development sites with several mapped hazard areas, including FEMA flood hazard areas, areas subject inundation with sea level rise (1, 3, and 10 feet), hot spots (hottest 5% surface temperatures in the MAPC region), landslide risk, snowfall, and wind speed. As shown in Table 34, Six of the 40 development sites are within an AE flood hazard zone (1% annual chance of flooding), and eleven others are partially within this hazard area. The analysis of potential sea level rise shows that three development sites would be partially inundated by one foot of sea level rise, and two sites would be inundated by three feet. The extreme scenario of ten feet of sea level rise would fully inundate 13 development sites and partially inundate another six sites. For landslide risk, all of the sites are within the zone of Moderate Susceptibility and Low Incidence; the entire City of Chelsea is within that zone. Likewise, all sites, and the entire City, are within the zone of 36 to 48 inches of annual average snowfall, and a zone of 100-year maximum wind speed of 110 miles per hour. Just one development site, 1001-1005 Broadway (#N) is within a hot spot area.

This information is provided so that planners can ensure that development proposals comply with floodplain zoning and that careful attention is paid to drainage, coastal impacts, heat, and other issues. The City requires a Special Permit for most properties in the Floodplain District and applies stormwater regulations to new developments. This indicates that Chelsea's development should not significantly increase the City's vulnerability if existing regulations are adhered to.

Table 34 Relationship of Development to Hazard Areas

Map#	Development Site	Acres	Flood Hazard Areas	SLR 1 Foot	SLR 3 Feet	SLR 10 Feet
COMPLETED DEVELOPMENTS						
B	85 - 87 Parker Street	0.2	97.18% AE: 1% with BFE			100.0% inundated
C	14 Williams/73 Winnisimmet	0.1				
D	13 - 15 Sixth Street	0.1				100.0% inundated
E	130 Eastern Ave	7.0	93.72% AE: 1% with BFE			100.0% inundated
F	25 Eleanor Street	0.2				99.31% inundated
G	13 - 15, 17 fifth Street	0.1				18.68% inundated
H	87 - 89 Parker Street	0.2	97.18% AE: 1% with BFE			100.0% inundated
I	22 Adams	0.1				
N	1001 - 1005 Broadway	0.7				99.54% inundated
O	208 Spencer Ave	0.1				
P	42 Blossom Street	0.1	67.26% AE: 1% with BFE			100.0% inundated
Q	235 Marginal Street	1.3	100.0% AE: 1% with BFE			100.0% inundated
R	35 Nichols Street	0.3				
S	200 (V) Maple Street	1.3	100.0% AE: 1% with BFE	8.93% inundated		100.0% inundated
T	121 Webster	3.5				
U	16 Fifth Street	0.0				5.67% inundated
W	157 Clark Ave	0.5				
X	5 - 79 Spencer Ave	0.1	100.0% AE: 1% with BFE			100.0% inundated
Y	80 Eastern Ave	1.2	10.04% AE: 1% with BFE			85.82% inundated
CC	52 Spencer Ave	0.1	49.26% AE: 1% with BFE			100.0% inundated
EE	932 Broadway	0.7				
II	13 - 15 Fifth Street	0.1				8.04% inundated
NEW DEVELOPMENTS						
A	200 Beacham	0.4	52.07% AE: 1% with BFE			100.0% inundated
J	157 Crescent Ave	0.4	100.0% AE: 1% with BFE	30.68% inundated		100.0% inundated
K	170 Cottage Street	1.2				4.1% inundated
L	1 Forbes Street	12.6	46.79% AE: 1% with BFE		26.05% inundated	92.14% inundated
M	176-178 Washington Ave.	0.2				93.3% inundated
V	54 Washington Ave	0.1				31.85% inundated

Map#	Development Site	Acres	Flood Hazard Areas	SLR 1 Foot	SLR 3 Feet	SLR 10 Feet
Z	201 Marginal Street	0.8	100.0% AE: 1% with BFE		41.8% inundated	100.0% inundated
AA	25 Sixth Street	0.7	18.02% AE: 1% with BFE			97.22% inundated
BB	170 Central Ave	2.3				39.5% inundated
DD	51 Crescent Ave	0.2				
FF	440 Broadway	0.2				
GG	45 Market Street	0.7	89.83% AE: 1% with BFE			100.0% inundated
HH	84 - 86 Blossom Street	0.1	100.0% AE: 1%with BFE			100.0% inundated
JJ	25 Second Street	0.3				
KK	926 Broadway	0.1				
LL	22 Willow & 250 Marginal	8.3	60.54% AE: 1% with BFE	10.41% inundated		88.06% inundated
MM	157 - 163 Chestnut St.	0.6				
NN	25 Griffin Way	1.3				0.36% inundated

Source: MAPC Data Services Department

Natural Resources and Development Patterns

The topography of Chelsea consists primarily of coastal lowlands, punctuated by four drumlins formed during the last Ice Age. These drumlins are located in the southwest (Admirals Hill), southeast (Mount Bellingham), northeast (Powder Horn Hill) and northwest (Mount Washington). A smaller drumlin (Mill Hill) is located on the east side of Chelsea, adjacent to Mill Creek. Soils in the City are primarily urban fill, and there is very little undeveloped land. The U.S. Soil Conservation Service identified four other major soil classifications. Woodbridge-Urban complex, Newport-Urban Complex, and Canton-Urban Complex comprise most of the City's land area not designated as urban. The Udorthents classification of wet substratum is found along portions of the City's waterfront. Chelsea has no undeveloped areas designated as prime agricultural land.

Most of the waterfront is used for industrial purposes and much of the hilltop areas are covered with residential development. Chelsea is bordered on three sides by water, giving the City a unique character and a potentially high degree of access to waterfront areas. The Mystic River borders Chelsea on the southwest, the Chelsea Creek and Mill Creek on the east, and the Island End River on the west. Mill Creek is bordered by marshy wetlands between the developed portions of the City and the creek itself. Chelsea Creek has a more abrupt shoreline, with filled areas dropping off quickly into the creek and industrial uses obscuring much of the access to the shore. The City's accessible frontage on the Mystic River is mostly in the Admiral's Hill area, which has banks gradually sloping down to the water on recreation land.

Chelsea's character is not only related to its adjacent rivers, but also to the character of its landscape. The land in Chelsea is occupied by the five glacial drumlins described above, rising 150'-200' above sea level. This sloped and hilly landscape helps to divide the City into discernible neighborhoods, each with its own character, thereby giving the City a manageable sense of scale and orientation. From the tops of these drumlins, there are dramatic views of Boston, Revere, and other surrounding areas. Despite the fact that in most of the City the natural landscape has been covered by development, Chelsea's topography and proximity to water remain dominant features. (Chelsea Open Space Plan).

CRITICAL FACILITIES

Critical Facilities include several categories of facilities and functions: those that provide utility for municipal operations or to provide emergency response (such as emergency operations centers, fire stations, public works yards, etc.); facilities that may require assistance during an emergency (such as nursing homes, elderly housing, day care centers, etc.), and critical infrastructure such as bridges, transit facilities, dams, water supply and wastewater pumping stations, and communications and energy facilities, The City identified 56 critical facilities, which are listed in Table 35 and are shown on the maps in Appendix A.

Table 35 - Chelsea Critical Facilities

Map#	Facility	Address	Type
1	Chelsea Street Bridge	Chelsea Street	Bridge
2	Tobin Bridge	Route 1	Bridge
3	Meridian Street Bridge	Meridian Street	Bridge
5	City Hall	500 Broadway	Municipal
6	Chelsea Courthouse	120 Broadway	Court House
7	CAPIC Head Start	69 Crescent Avenue	Child Care
8	Best Friends Learning Center	950 Broadway	Child Care
9	Chelsea City Yard	280 Beacham Street	Municipal
10	Chelsea Senior Center	10 Riley Way	Senior Center
11	Margolis Apartments	260 Clark Avenue	Elder Housing
12	Buckley Apartments	14 Bloomingdale Street	Elder Housing
13	NSTAR Substation	Willoughby Street	Power Substation
14	Emergency Operations & Communications Center	45 Washington Avenue	Emergency Operations Center
15	Chelsea Engine 3 Fire Station	883 Broadway	Fire Station
16	Chelsea Engine 1 Fire Station	34 Sagamore Avenue	Fire Station
17	Chelsea Central Fire Station	307 Chestnut Street	Fire Station
18	Kayem Foods Inc.	75 Arlington Street	Grocery Store
19	Gulf Oil	295 Eastern Avenue	Gas Distribution
20	Alliance Fuel	11 Broadway	Gas Distribution
42	Massachusetts Information Technology Center	200 Arlington Street	Information Technology
22	Senior Living Bellingham Hill	100 Bellingham Street	Elder Housing
23	Chelsea Jewish Nursing Home	17 Lafayette Avenue	Elder Housing
25	Chelsea Police	19 Park Street	Police Station
26	Verizon Phone Transfer Station	1 City Hall Avenue	Telecommunications
27	U.S. Postal Incoming Mail Center	380 Beacham Street	Post Office
28	Shurtleff Early Learning Center	99 Hawthorn Street	School
29	Chelsea High School	299 Everett Avenue	School
30	Bunker Hill Community College	175 Hawthorne Street	School

Map#	Facility	Address	Type
31	Williams Middle School	180 Walnut Street	School
32	St. Rose Elementary School	580 Broadway	School
33	Clark Avenue School	8 Clark Avenue	School
34	Burke School Complex	300 Crescent Avenue	School
36	Massachusetts State Soldiers Home/Hospital	91 Crest Avenue	Hospital
37	Mass Water Resources Authority	2 Griffin Way	State Office
38	Mass Water Resources Authority	340 Marginal Street	State Office
39	Chelsea Pump Station	Carter Street and Second Street	Water Pump Station
40	Chelsea Commuter Rail Station		Transportation
41	Market Basket		Food
43	MGH Urgent Care		Medical
44	Chelsea Commuter Rail Station (Soon to be closed)		Transportation
45	Silver Line Stop		Transportation
46	Silver Line Stop		Transportation
47	Beth Israel Urgent Care		Medical
48	Mill Creek Bridge		Bridge
49	Silver Line T Stop	Transportation	
50	Admiral's Way backup emergency comms radio	5 Admiral's Way	Communications
51	New England Produce Center: Regional food distribution		Food Distribution
52	Market Street Culvert Outfall		Stormwater
53	Beacham Street culvert inlet		Stormwater
54	Market Street drainage ditch		Stormwater
55	Spruce Street drain outfall		Stormwater
56	Admiral's Hill booster pump station		Water Infrastructure

Critical Infrastructure in Hazard Areas

MAPC conducted a GIS mapping analysis in order to determine where critical facilities are located in one or more of the mapped hazard areas, to better understand which facilities may be vulnerable to particular natural hazards. The hazards included are FEMA flood hazard areas, areas subject inundation with sea level rise (1, 3, and 10 feet), hot spots (hottest 5% surface temperatures in the MAPC region), landslide risk, snowfall, and wind speed. Table 36 shows the results of this analysis.

It should be noted that several categories of hazards are City-wide and do not vary from site to site.

- Landslides: Moderate Susceptibility and Low Incidence
- Snowfall: Average annual 36 to 48 inches
- Temperature: 100-year maximum of 100 degrees F.

Explanation of Columns in Table 36

- ***Column 1: MAP #:*** The first column is an ID number which appears on the maps that are part of this plan. See Appendix A.

- ***Column 2: Facility Name****:* The second column is the name of the facility

- ***Column 3: FEMA Flood Zone*****:** The third column addresses the risk of flooding according to Special Flood Hazard Areas delineated on the Flood Insurance Rate Maps.. A "No" entry in this column means that the site is not within any of the mapped risk zones on the Flood Insurance Rate Maps (FIRM maps). If there is an entry in this column, it indicates the type of flood zone as follows:

    - **Zone A** Areas subject to inundation by the 1-percent-annual-chance flood event. Because detailed hydraulic analyses have not been performed, no Base Flood Elevations (BFEs) or flood depths are shown. Mandatory flood insurance purchase requirements and floodplain management standards apply.
    - **Zone AE** Areas subject to inundation by the 1-percent-annual-chance flood event determined by detailed methods. Base Flood Elevations (BFEs) are shown. Mandatory flood insurance purchase requirements and floodplain management standards apply.
    - **Zone AH** Areas subject to inundation by 1-percent-annual-chance shallow flooding (usually areas of ponding) where average depths are 1–3 feet. BFEs derived from detailed hydraulic analyses are shown in this zone. Mandatory flood insurance purchase requirements and floodplain management standards apply.
    - **Zone X (shaded)** Moderate risk areas within the 0.2-percent-annual-chance floodplain, areas of 1-percent-annual-chance flooding where average depths are less than 1 foot, areas of 1-percent-annual-chance flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 1-percent-annual-chance flood by a levee. No BFEs or base flood depths are shown within these zones. (formerly Zone B)
    - **Zone X (unshaded)** Minimal risk areas outside the 1-percent and .2 percent-annual-chance floodplains. No BFEs or base flood depths are shown within these zones. (formerly Zone C)

- Column 4: **Area Inundated by 1 foot of Sea Level Rise** from the Boston Harbor SLR model

- Column 5: **Area Inundated by 3 feet of Sea Level Rise** from the Boston Harbor SLR model

- Column 6: **Area Inundated by 10 feet of Sea Level Rise** from the Boston Harbor SLR model

- Column 7: **Hot spots** indicates areas that are within the 5% of hottest areas in the MAPC region based on satellite data from 2016

Table 36 - Critical Facilities and Relationship to Hazard Areas

ID	Facility Name	FEMA Flood Zone	Inundated by 1 ft Sea Level Rise	Inundated by 3 ft Sea Level Rise	Inundated by 10 ft Sea Level Rise	Hot Spot
1	Chelsea Street Bridge	AE: 1% with BFE	No	No	Yes	No
2	Tobin Bridge	No	No	No	No	No
3	Meridian Street Bridge	AE: 1% with BFE	No	Yes	Yes	No
5	City Hall	No	No	No	No	No
6	Chelsea Courthouse	No	No	No	No	No
7	CAPIC Head Start	No	No	No	Yes	No
8	Best Friends Learning Center	No	No	No	No	No
9	Chelsea City Yard	X: 0.2%	No	No	Yes	No
10	Chelsea Senior Center	No	No	No	No	No
11	Margolis Apartments	No	No	No	No	No
12	Buckley Apartments	No	No	No	Yes	No
13	NSTAR Substation	AE: 1% with BFE	Yes	No	Yes	No
14	Emergency Operations & Communications Center	No	No	No	No	No
15	Chelsea Engine 3 Fire Station	No	No	No	No	No
16	Chelsea Engine 1 Fire Station	No	No	No	No	Yes
17	Chelsea Central Fire Station	No	No	No	No	No
18	Kayem Foods Inc.	AE: 1% with BFE	No	No	Yes	No
19	Gulf Oil	No	No	No	Yes	No
20	Alliance Fuel	AE: 1% with BFE	No	No	Yes	No
42	Massachusetts Information Technology Center	AE: 1% with BFE	No	No	Yes	No
22	Senior Living Bellingham Hill	No	No	No	No	No
23	Chelsea Jewish Nursing Home	No	No	No	No	No
25	Chelsea Police	No	No	No	No	No
26	Verizon Phone Transfer Station	No	No	No	No	No
27	U.S. Postal Incoming Mail Center	AE: 1% with BFE	No	No	Yes	No
28	Shurtleff Early Learning Center	No	No	No	No	No

ID	Facility Name	FEMA Flood Zone	Inundated by 1 ft Sea Level Rise	Inundated by 3 ft Sea Level Rise	Inundated by 10 ft Sea Level Rise	Hot Spot
29	Chelsea High School	AE: 1% with BFE	No	No	Yes	No
30	Bunker Hill Community College	No	No	No	No	No
31	Williams Middle School	No	No	No	Yes	No
32	St. Rose Elementary School	No	No	No	No	No
33	Clark Avenue School	No	No	No	No	No
34	Burke School Complex	AE: 1% with BFE	No	No	Yes	No
36	Massachusetts State Soldiers Home/Hospital	No	No	No	No	No
37	MWRA Offices	No	No	No	Yes	No
38	MWRA Offices	AE: 1% with BFE	No	No	Yes	No
39	Chelsea Pump Station	AE: 1% with BFE	No	No	Yes	No
40	Chelsea Commuter Rail Station	AE: 1% with BFE	No	No	Yes	No
41	Market Basket	AE: 1% with BFE	No	No	Yes	No
43	MGH Urgent Care	AE: 1% with BFE	No	No	Yes	No
44	Chelsea Commuter Rail Station (Soon to be closed)	AE: 1% with BFE	No	No	Yes	No
45	Silver Line Stop	AE: 1% with BFE	No	No	Yes	No
46	Silver Line Stop	No	No	No	Yes	No
47	Beth Israel Urgent Care	No	No	No	Yes	No
48	Mill Creek Bridge	AE: Reg. Floodway	No	Yes	Yes	No
49	Silver Line T Stop	AE: 1% with BFE	No	No	Yes	No
50	Admiral's Way backup emergency comms radio	No	No	No	No	No
51	New England Produce Center: Regional food distribution	AE: 1% with BFE	No	No	Yes	No
52	Market Street Culvert Outfall	AE: 1% with BFE	No	Yes	Yes	No
53	Beacham Street culvert inlet	No	Yes	No	Yes	No
54	Market Street drainage ditch	No	No	No	Yes	No
55	Spruce Street drain outfall	No	No	No	Yes	No
56	Admiral's Hill booster pump station	No	No	No	No	No

VULNERABILITY ASSESSMENT

The purpose of the vulnerability assessment is to estimate the extent of potential damages from natural hazards of varying types and intensities. A vulnerability assessment and estimation of damages was performed for hurricanes, earthquakes, and flooding through FEMA's HAZUS-MH software.

Introduction to HAZUS-MH

HAZUS- MH (multiple-hazards) is a computer program developed by FEMA to estimate losses due to a variety of natural hazards. The following overview of HAZUS-MH is taken from the FEMA website. For more information on the HAZUS-MH software, go to https://www.fema.gov/hazus/

"HAZUS-MH is a nationally applicable *standardized methodology and software program that contains models for estimating potential losses from earthquakes, floods, and hurricane winds. HAZUS-MH was developed by the Federal Emergency Management Agency (FEMA) under contract with the National Institute of Building Sciences (NIBS). Loss estimates produced by HAZUS-MH are based on current scientific and engineering knowledge of the effects of hurricane winds, floods, and earthquakes. Estimating losses is essential to decision-making at all levels of government, providing a basis for developing and evaluating mitigation plans and policies as well as emergency preparedness, response, and recovery planning.

HAZUS-MH uses state-of-the-art geographic information system (GIS) software to map and display hazard data and the results of damage and economic loss estimates for buildings and infrastructure. It also allows users to estimate the impacts of hurricane winds, floods, and earthquakes on populations."

There are three modules included with the HAZUS-MH software: hurricane wind, flooding, and earthquakes. There are also three levels at which HAZUS-MH can be run. Level 1 uses national baseline data and is the quickest way to begin the risk assessment process. The analysis that follows was completed using Level 1 data.

Level 1 relies upon default data on building types, utilities, transportation, etc. from national databases as well as census data. While the databases include a wealth of information on the City of Chelsea, it does not capture all relevant information. In fact, the HAZUS training manual notes that the default data is "subject to a great deal of uncertainty."

However, for the purposes of this plan, the analysis is useful. This plan is attempting to generally indicate the possible extent of damages due to several types of natural disasters and to allow for a comparison between different types of disasters. Therefore, this analysis should be considered to be a starting point for understanding potential damages from the hazards. If interested, communities can build a more accurate database and further test disaster scenarios.

ESTIMATED DAMAGES FROM HURRICANES

The HAZUS software was used to model potential damages to the community from a 100 year and 500-year hurricane event; storms that are 1% or 0.1 and 0.2% or 0.002 likely to happen in a given year and roughly equivalent to a Category 2 and Category 4 hurricane. The damages caused by these hypothetical storms were modeled as if the storm track passed directly through the Town, bringing the strongest winds and greatest damage potential.

Though there are no recorded instances of a hurricane equivalent to a 500-year storm passing through Massachusetts, this model was included in order to present a reasonable "worst case scenario" that would help planners and emergency personnel evaluate the impacts of storms that might be more likely in the future, as we enter into a period of more intense and frequent storms.

Table 37: Estimated Damages from Hurricanes

	100-Year	500_Year
Building Characteristics		
Estimated total number of buildings	5,367	
Estimated total building replacement value (2014 $)	$3,535,980	
Building Damages		
# of buildings sustaining minor damage	229	1,046
# of buildings sustaining moderate damage	48	343
# of buildings sustaining severe damage	2	27
# of buildings destroyed	0	3
# Total building with damages	279	1,419
Population Needs		
# of households displaced	4	160
# of people seeking public shelter	2	126
Debris		
Total Debris (tons)	3,848	14,289
Building debris generated (tons)	3,524	882
Tree debris generated (tons)	324	13,047
# of truckloads to clear building debris	141	536
Value of Damages		
Property damage (buildings and content)	$22,430,370	$101,523,800
Losses due to business interruption	$2,152,460	$12,358,190
Total of All Losses	$24,582,830	$113,881,990

ESTIMATED DAMAGES FROM EARTHQUAKES

The HAZUS earthquake module allows users to define an earthquake magnitude and model the potential damages caused by that earthquake as if its epicenter had been at the geographic center of the study area. For the purposes of this plan, two earthquakes were selected: magnitude 5.0 and a magnitude 7.0. Historically, major earthquakes are rare in New England, though a magnitude 5 event occurred in 1963.

Table 38: Estimated Damages from Earthquakes

	Magnitude 5.0	Magnitude 7.0
Building Characteristics		
Estimated total number of buildings	5,367	
Estimated total building replacement value (2014 $)	$3,535,980	
Building Damages		
# of buildings sustaining slight damage	1,296	351
# of buildings sustaining moderate damage	918	990
# of buildings sustaining extensive damage	364	1,103
# of buildings completely damaged	109	2,774
# Total building with damages	2,687	5,218
Population Needs		
# of households displaced	889	7,830
# of people seeking public shelter	796	6,917
Debris		
Building debris generated (tons)	143,000	960,000
# of truckloads to clear debris (@ 25 tons/truck)	5,720	38,400
Value of Damages		
Property damage (buildings and contents)	$484,770,300	$3,262,300,500
Losses due to business interruption	$95,953,200	$500,530,700
Total of All Losses	$580,720,000	$3,762,830,000

ESTIMATED DAMAGES FROM FLOODING

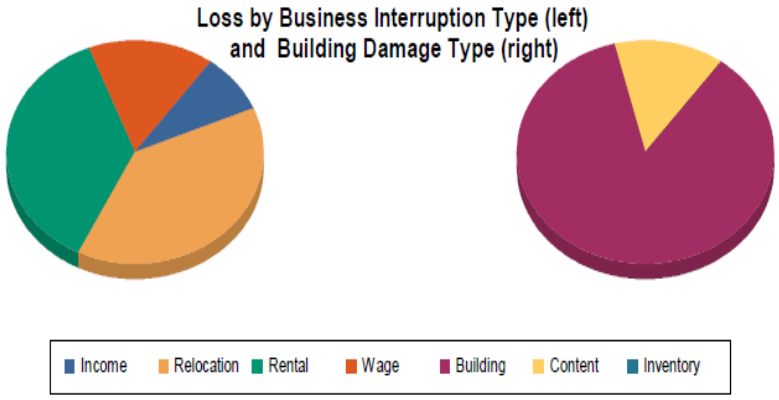
The HAZUS flooding module allows users model the potential damages caused by a 100-year flood event and a 500-year flood event.

Table 39: Estimated Damages from Flooding

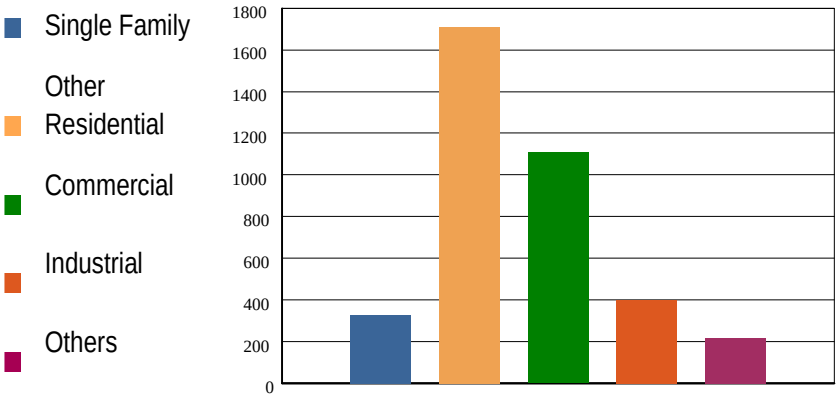
	100-Year Flood	500-Year Flood
Building Characteristics		
Estimated total number of buildings	5,367	
Estimated total building replacement value (2014 $)	$3,535,980	
Building Damages		
# of buildings sustaining limited damage	21	81
# of buildings sustaining moderate damage	2	17
# of buildings sustaining extensive damage	2	1
# of buildings substantially damaged	3	4
# Total building with damages	28	103
Population Needs		
# of households displaced	62	324
# of people seeking public shelter	1,067	3,480
Value of Damages		
Building Losses	$64,560,000	$500,930,000
Losses due to business interruption	$76,540,000	$253,470,000
Total of All Losses	$141,100,000	$754,400,000

Figure 28: HAZUS Loss Estimates by Type

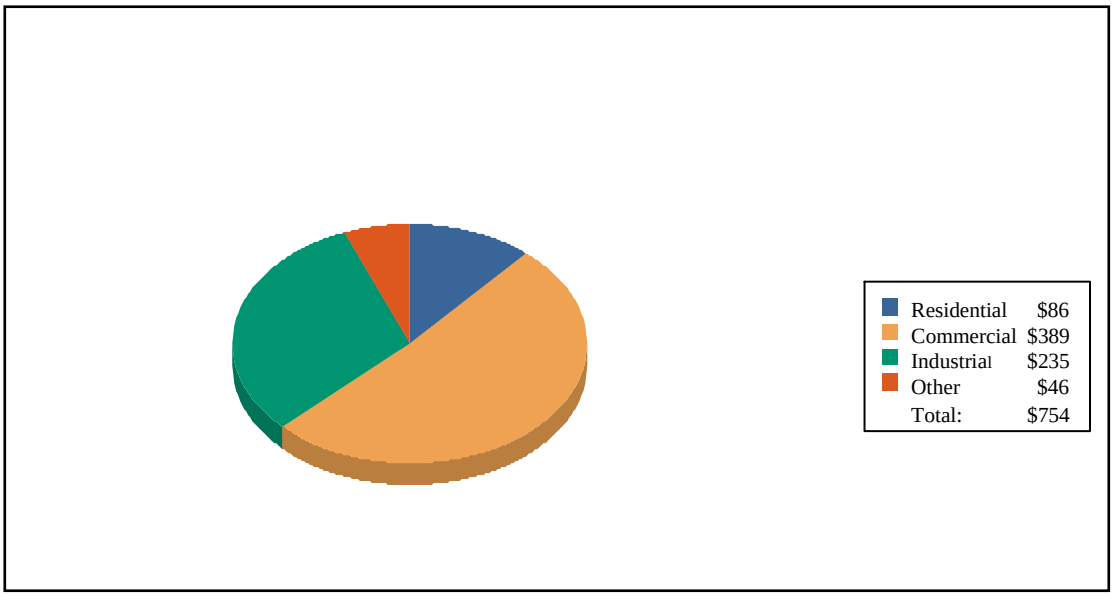
28-A Hurricane Loss by Business and Occupancy Type



28-B Earthquake Loss by Occupancy Type



28-C Flood Loss by Occupancy Type



IMPACTS ON PEOPLE AND VULNERABLE POPULATIONS

Just as some locations in Chelsea will be more vulnerable to natural hazard and climate change impacts than others, it is also true that these hazards will not affect all residents of Chelsea equally. People who may be more susceptible to negative health effects can include older adults, young children, pregnant women, people with disabilities, and people with pre-existing health conditions, as they are more likely to be physically vulnerable to the health impacts of extreme heat and poor air quality. Individuals with physical mobility constraints may need additional assistance with emergency response. Older adults are often at elevated risk due to a high prevalence of pre-existing and chronic conditions. People who live in substandard housing and in housing without air conditioning have increased vulnerability to heat-related illnesses. Black and Latino residents in Massachusetts are hospitalized for asthma at considerably higher rates than the population as whole, reflecting the reality that longstanding societal inequities can lead to differential health outcomes based on race and ethnicity.

Low-income people are often more susceptible to financial shocks, which can occur after extreme weather, and which can impact financial security and the ability to secure safe shelter and meet medical needs. Social and linguistic isolation can also influence vulnerability, as it limits access to critical information, municipal resources, and social support systems. In the absence of strong social support networks and translation services, people living alone and those with limited English language proficiency may experience social isolation. Certain occupations may also experience more severe impacts. People who work outdoors, or in unregulated temperatures, are at increased risk for heat-related illnesses.

In developing mitigation measures the City will need to continue to address the needs of all of its residents. In Chelsea 18% of residents are below the poverty level. Over 39% of residents are limited English speakers, and 69% speak a language other than English at home. Residents over age 65 represent nearly 10% of the City's population, and 13% of residents have a disability. (American Community Survey, 2019). While this is challenging, the City has made significant efforts to address these needs, partnering with community-based organizations such as GreenRoots and the Chelsea Collaborative.

In addition to social impacts, the built environment and natural resources are vulnerable to the impacts of natural hazards and climate change. Table 37 summarizes hazard risks across all three categories of impacts.

Table 40: Summary of Hazard Risks for Society, Built Environmetn, and Natural Resources

CLIMATE CHANGE	NATURAL HAZARD	KEY CONCERNS SOCIETY	KEY CONCERNS BUILT ENVIRONMENT	KEY CONCERNS NATURAL RESOURCES
Changes in Precipitation 	Inland Flooding	Elderly residents and environmental justice populations; property damage; Impacts on businesses	Roadway closures , damage to buildings; impacts on infrastructure	Pollutants, erosion, scouring, damage to habitat
	Drought	Increases costs for irrigation, drinking water supply	Impacts on landscaped areas, parks, playing fields, etc.	Impacts on streams, wetlands, vegetation
	Landslide	Private property damage	Damage to buildings and infrastructure	Erosion, sedimentation
Sea Level Rise 	Coastal Flooding	Property damage, impacts on businesses	Roadway closures , damage to buildings; impacts on infrastructure	Damage to coastal habitat
	Tsunami	Property damage, loss of life	Damage to buildings and infrastructure	Damage to habitat
Rising Temperatures 	Average and Extreme Temperatures	Elderly populations if no access to cooling or financial resources to buy an AC		Increasing invasives, stress on resources
	Wildfires	Air Quality - Smoke	Damage to buildings	Damage to resources
	Invasive species	Potential health impacts of pests	Impaired use of park and open space	Loss of biodiversity
Extreme Weather 	Hurricanes / Tropical Storms	Power outages; property damage, impacts to businesses	Street closures, house flooding, emergency access, wind damage to buildings, power outages	Tree damage
	Severe Winter Storms	Power outages, elderly, or isolated residents	Damage to public buildings with snow loads, power outages that can affect municipal operations, road blockages.	Tree damage
	Tornadoes	Property damage, impacts on businesses	Damage to buildings and infrastructure	Tree damage
	Thunderstorms/ Microbursts)	Power outages, property damage	Power loss, road closures (same as above)	Tree damage
Non-Climate Hazard	Earthquake	Property damage, impacts on businesses	Damage to buildings and Infrastructure	Landslides

SECTION 5: HAZARD MITIGATION GOALS

The Chelsea Hazard Mitigation Planning Team reviewed and reviewed and endorsed the goals from the 2017 Hazard Mitigation Plan. All of the goals are considered critical for the city, and they are not listed in order of importance. The Team also chose to add new goals for this 2022 plan update to address climate change and equity issues, Goals 10 and 11.

1. Prevent and reduce the loss of life, injury and property damages resulting from all major natural hazards.

2. Identify and seek funding for measures to mitigate or eliminate each known significant flood hazard area.

3. Integrate hazard mitigation planning as an integral factor in all relevant municipal departments, committees, and boards.

- Continue to use the CIP as a tool for accomplishing mitigation projects.
- Ensure that the Planning Department considers hazard mitigation in its review and permitting of new development.
- Review zoning regulations to ensure that the ordinance incorporates all reasonable hazard mitigation provisions.
- Ensure that the Building Dept. has the resources to enforce building regulations.

4. Prevent and reduce the damage to public infrastructure resulting from all hazards. Begin to assess the vulnerability of municipal buildings and infrastructure to damage from an earthquake and maintain existing mitigation infrastructure in good condition.

5. Encourage the business community, major institutions, and non-profits to work with the City to develop, review and implement the hazard mitigation plan.

6. Work with surrounding communities, state, regional and federal agencies to ensure regional cooperation and solutions for hazards affecting multiple communities. Continue to participate in the Mystic Region LEPC.

7. Ensure that future development meets federal, state, and local standards for preventing and reducing the impacts of natural hazards.

8. Educate the public about natural hazards and mitigation measures that can be undertaken by property-owners. Provide information on hazard mitigation activities in the languages most frequently spoken in Chelsea.

9. Take maximum advantage of resources from FEMA and MEMA to educate City staff and the public about hazard mitigation.

10. Consider the impacts of climate change. Incorporate climate sustainability and resilience into hazard mitigation planning and the Town's other plans and policies.

11. Ensure that the City's Hazard Mitigation efforts consider the impacts of natural hazards on vulnerable populations and address their needs for mitigation.

SECTION 6: EXISTING MITIGATION MEASURES

The existing protections in the City of Chelsea are a combination of zoning, land use, and environmental regulations, infrastructure maintenance, and drainage infrastructure improvement projects. Infrastructure maintenance generally addresses localized drainage clogging problems, while large scale capacity problems may require pipe replacement or invert elevation modifications. These more expensive projects are subject to the capital budget process and lack of funding is one of the biggest obstacles to completion of some of these.

The City's existing mitigation measures are listed by hazard type here and are summarized in Table 36 below. Upgrades to existing measures and new measures are noted as well.

Multiple Hazard Mitigation Measures

Massachusetts State Building Code – The Massachusetts State Building Code contains many detailed regulations regarding wind loads, earthquake resistant design, flood-proofing, and snow loads.

Mystic Region Emergency Management Planning Committee (REPC) – Chelsea is a member of a regional emergency planning committee with Revere, Everett, Lynn, Malden, Medford, Melrose, North Reading, Reading, Saugus, Somerville, Stoneham, Wakefield, Winchester, Winthrop, and Woburn. The City plans to continue to participate in this regional committee.

Comprehensive Emergency Management Plan (CEMP) – Every community in Massachusetts is required to have a Comprehensive Emergency Management Plan. These plans address mitigation, preparedness, response, and recovery from a variety of natural and man-made emergencies. These plans contain important information regarding flooding, hurricanes, tornadoes, dam failures, earthquakes, and winter storms. Therefore, the CEMP is a mitigation measure that is relevant to most of the hazards discussed in this plan. Chelsea's CEMP is being updated and is expected to be completed by July 1, 2022.

Communications Equipment – The City has its own Mobile Command Unit and also utilizes the MA emergency Incident Command Unit a mobile communications center available to the City through the MA State Police and the MA Department of Fire Services. The City has a Reverse 911 system which is to be to be expanded from only City Manager and Police Chief to also include Emergency Management and the Fire Department.

Communication System Updated through Capital Improvement Plan Finances towards new Radio System Upgrades for Police, Fire, Emergency Services, and the Department of Public Work.

Emergency Power Generators – Emergency power generators are in place in the three Red Cross certified emergency shelters- the Chelsea Senior High School, Williams Middle School, and the Mary C. Burke School. All fire and police stations and the Emergency Call Center have backup emergency generators.

The City seeks to install solar powered batteries at City Hall, and Police Station. Install battery at multiple city owned buildings and TND property for microgrid.

Flooding Hazard Mitigation Measures

Storm Drain System- Regular cleaning of the City's 1,500 catch basins is conducted in accordance with the requirements of the MS4 Stormwater Permit issued by the Environmental Protection Agency under the Clean Water Approximately 50% of the sewer collection system in the City of Chelsea is combined sanitary sewer and storm sewer, down from 75% ten years ago as Chelsea has engaged in a methodical capital improvements planning process, with sewer/storm drain separation included in that effort. In addition, Chelsea's streets are swept twice monthly from March – November and it has reduced the sand used on its roads during the winter season.

Chelsea's Capital Improvement Program assesses capital expenditures for water, sewer, and drainage projects. Since 2008, the City has continued to update and implement actions from its Capital Improvements Plan relating to flooding and stormwater infrastructure improvements including the following:

- Willow and Central Ave Infrastructure Improvement project will redirect storm water flowing Willow Street onto Central Ave.
- Island End River design underway
- Beacham Street project installed new drainage system to capture and covey runoff.
- Chelsea has reduced inflow and infiltration into the City's sanitary sewer collection system and separated stormwater drainage from its sewer system. This has helped to reduce flooding during high water runoff periods, particularly in low- lying areas.
- The Highland Street Drainage Outfall provides an outlet for storm water in the vicinity of Marginal Street and Highland Street and has reduced flooding in this area.
- The Marginal Street tide gate replacement project prevents high tide water from entering the storm drain outfall system and flooding the neighborhood.
- The City designed and constructed infrastructure improvements on Jefferson Avenue and Everett Avenue to update water mains, storm drain lines and sewer lines.

National Flood Insurance Program (NFIP) – Chelsea participates in the NFIP with 32 policies in force as of December 31, 2015. FEMA maintains a database on flood insurance policies and claims.

Since the 2017 plan, the policies in force have increased significantly from 32 to 245, with 173 of these residential properties and 72 are non-residential properties. Of the 245 insured properties, 75 are located in FEMA flood hazard Zones A or AE (1% annual chance of flooding) and 170 are in Zones B, C, or X (0.2% annual chance of flooding). Total premiums paid were $422,531, and total claim payments were $81,629 as of 2021.

The City complies with the NFIP by enforcing floodplain regulations, maintaining up-to-date floodplain maps, and providing information to property owners and builders regarding floodplains and building requirements. The City is considering implementing the Community Rating System (CRS) through the North Suffolk Regional Sustainability Office.

The following information is provided for the City of Chelsea:

Flood insurance policies in force (as of 7/9/21)	245
Coverage amount of all flood insurance policies in force	$100,186,400
Premiums paid	$422,531
Closed losses (Losses that have been paid)	28
Total payments (Total amount paid on losses)	$81,629

Combined sewer separation – The City receives funding for sewer and drainage improvements through the Massachusetts Water Resources Authority (MWRA). Funds are available as a 25% grant and 75% loan for eligible activities.

Zoning ordinance – The City restricts development under its floodplain district zoning ordinance. The zoning ordinance contains a number of provisions that mitigate flooding problems. These include:

- The section on performance standards includes a requirement for erosion control. This provision requires that when any alterations are made to the contours of the land, there shall be no alteration of the runoff of water to or from abutting properties. (Section 34-110(1))
- Section 34-214(d) concerns the requirements for a development impact statement which may be required by the special permit granting authority. The impact statement must include information on surface water and subsurface conditions.

Subdivision regulations – Section IV.F.4 states that no net increase in runoff due to the development of a subdivision shall be allowed. It also requires that retention/detention basins shall be included in the design as necessary, using the 100-year design storm event.

Stormwater Management Ordinance – In 2020 the Public Works Department updated the City's Stormwater Ordinance to comply with requirements of the EPA MS4 Stormwater Permit. The section of the ordinance that was updated is Article 5, Sewers, and Drains, including Section 30-218, Building Strom Drains and Connections; Section 30-220, Pollution Prevention in the Stormwater Collection System; and Section 30-223, Stormwater Management. Low Impact Development The ordinance requires that development plans must include provisions for low impact development (LID) site planning and design strategies to be used to the maximum extent feasible, addressing the following LID principles:

a. Preservation of natural areas
b. Tree protection
c. Vegetation and landscaping
d. Riparian buffer protection
e. Limit land disturbance during construction
f. Limit new impervious surfaces
g. Promote the use of vegetative (green infrastructure) stormwater controls
h. Disconnect flow paths
i. Promote infiltration
j. Capture and reuse stormwater

Green Infrastructure- In 2011, EPA announced its green infrastructure partnership with the City of Chelsea. As part of a nation-wide effort to encourage and support the expanded uses of green

infrastructure in partner communities, EPA Region 1 commended Chelsea for being a green infrastructure leader in this watershed by installing tree boxes along Chester Avenue and other low impact stormwater mitigation strategies in their highly urbanized and industrialized environment. Technical assistance from Horsley Witten Group, Inc., along with input from the Chelsea Department of Public Works and the Chelsea Department of Planning & Development, resulted in a series of deliverables to help identify and address the barriers posed by local codes and ordinances, and to recommend a suite of green infrastructure practices suitable for Chelsea's poorly draining soils.

Extreme Temperature Mitigation Measures

The City maintains a link on its City web page to the Center for Disease Control web page on actions on how to prevent overheating. The City has collected ongoing data on internal (building) and external (built environment) urban heat index parameters. The City is implementing urban heat mitigation techniques via heat pumps, AC units, increased tree canopy, and increased heat resilience via splash features and shade structures

Wind Mitigation Measures

CEMP – The Chelsea Comprehensive Emergency Management Plan contains a section on high winds such as hurricanes and tornadoes. It lists several mitigation recommendations:

- Develop and disseminate emergency public information and instructions concerning hurricane preparedness and safety.
- Develop and enforce building codes to enhance structural resistance to high winds. Build new construction in areas that are not vulnerable to direct hurricane effects.
- Maintain plans for managing all hurricane emergency response activities.

Tree-trimming program – The City contracts out 100% of its work to trim and remove trees as needed and grind stumps. National Grid maintains its power line corridors. DPW will continue citywide evaluation to locate problem trees.

Wireless Communications Facilities Overlay District- The Zoning Ordinance regulates and allows for review of the siting and placement of wireless communications facilities, including towers and antennas.

Massachusetts State Building Code - The City has adopted the Massachusetts State Building Code. The Massachusetts State Building Code contains detailed regulations regarding wind loads. The code's provisions are the most cost-effective mitigation measure against tornados given the extremely low probability of occurrence. If a tornado were to occur in Chelsea, damages would be extremely high due to the prevalence of older construction and the density of development.

Severe Winter Weather Hazard Mitigation Measures

Snow disposal – The City conducts regular plowing and snow/ice removal. Calcium chloride is used primarily for road treatments. Sand is very rarely used as it creates siltation and clean up problems. The DPW works to clear roads as requested or in an emergency for the Fire and Police Departments. The City has a snow disposal site at 295 Eastern Avenue. Reverse 911 and social media are used to notify the public of snow emergencies.

Geologic Hazard Mitigation Measures

Massachusetts State Building Code – The City enforces the State Building Code. It contains a section on designing for earthquake loads (780 CMR 1612.0). Section 1612.1 states that the purpose of these provisions is "to minimize the hazard to life to occupants of all buildings and non-building structures, to increase the expected performance of higher occupancy structures as compared to ordinary structures, and to improve the capability of essential facilities to function during and after an earthquake". This section goes on to state that, due to the complexity of seismic design, the criteria presented are the minimum considered to be "prudent and economically justified" for the protection of life safety. The code also states that absolute safety and prevention of damage, even in an earthquake event with a reasonable probability of occurrence, cannot be achieved economically for most buildings.

Section 1612.2.5 sets up seismic hazard exposure groups and assigns all buildings to one of these groups according to Table 1612.2.5. Group II includes buildings which have a substantial public hazard due to occupancy or use and Group III are those buildings having essential facilities which are required for post-earthquake recovery, including fire, rescue and police stations, emergency rooms, power-generating facilities, and communications facilities.

In the event of an earthquake and fires caused by it, 100 % of Chelsea is served by fire hydrants. The City DPW has two mobile, 5Kw generators in case of power loss The fire department has a mobile, 5 Kw generator, a mobile light tower and two electronic message boards. The City also has access Massachusetts Water Resource Authority (MWRA) diesel and gas pumps for flooding and other emergencies.

The City has installed under drains in selected sections of Powder Horn Hill to relieve water seepage. The City is reviewing and restoring areas where retaining walls are at risk of being undermined. Also concern that increased precipitation and freeze/thaw may have impact.

Wildland/Brush Fires Mitigation Measures

Burn Permits – The City fire department does not allow outdoor burning.

Fire Response-Chelsea responds to a brush or wildland fire in the same manner as other fire calls. It does not have a dedicated Forestry Division.

Subdivision/Development Review – The Fire Department participates in the review of new subdivisions and development/redevelopment projects to ensure that proper fire safety provisions are incorporated.

MetroFire- Chelsea belongs to the 34-member MetroFire. MetroFire is an association of Fire Departments in the Metropolitan Boston area to coordinate Mutual Aid and to act as a common entity for improving the overall effectiveness of their Fire and Emergency Medical Services.

A summary of the City's existing mitigation measures and updates for this 2022 plan update are found in Table 41.

Regional Initiative: Lower Mystic Regional Climate Assessment

This project was carried out by the cities of Boston, Chelsea, Everett, Revere, Somerville, and Winthrop, which are members Resilient Mystic Collaborative. The Mystic River Watershed Association and several Community Based Organizations and consultants assisted with the project.

Based on the results of nearly a year of one-on-one meetings with infrastructure facility managers, state and federal emergency managers, and outside experts from other cities, the Lower Mystic Working Group pursued a three-part strategy to identify and prioritize critical climate resilient investments:

1. Designed and held a functional exercise with 13 critical infrastructure facilities to identify site-specific and cascading failures caused by a projected winter Nor'easter with a 1% annual chance of occurring in 2050. Under this type of scenario, coastal flooding would be expected to be 2.5 feet higher than today.

2. Took the results of the infrastructure exercise and combined them with other well-documented impacts on vulnerable populations that result from critical infrastructure disruptions in order to develop an engagement strategy designed to understand the lived experience of residents and workers expected to be most negatively affected by damage to critical regional infrastructure.

3. Analyzed the results of these two assessments together, resulting in equity-informed findings and our recommendations for immediate and longer-term actions that will increase our resilience to these storms across the region. The project's recommendations are summarized below.

1. Incorporate social resilience into vulnerability assessments and benefit-cost analyses.

2. Prioritize transportation corridors for essential workers during and immediately after extreme weather events.

3. Develop and implement communications channels and strategies designed specifically to reach socially vulnerable populations in their first languages.

4. Develop and implement communications channels and strategies designed specifically to reach socially vulnerable populations in their first languages.

5. Prioritize making internet and cell phone communications infrastructure storm resilient.

6. Decrease dependence on the power grid and generators.

For a full description of the methods, findings, and recommendations, refer to the Lower Mystic Regional Resilience Report.

Table 41- Chelsea Existing Mitigation Measures

Mitigation Measure	Area Covered	Effectiveness	Updates for 2022 Changes Needed ?
MULTIPLE HAZARDS			
Comprehensive Emergency Management Plan (CEMP)	City-wide.	Emphasis on emergency response.	Update In Process, Estimated Completion Date July 1, 2022.
Communications Equipment: • Reverse 911-Code Red • Member of Metro Boston Homeland Security Region, designated as an "Urban Area"	City-wide.	Effective.	Reverse 911 System to be Expanded from only City Manager and Police Chief to Emergency Management and Fire Department Communication System Updated through Capital Improvement Plan Finances towards new Radio System Upgrades for Police, Fire, Emergency Services, and the Department of Public Work
Massachusetts State Building Code	City-wide.	Effective for new construction.	None
Emergency Generators	Chelsea Senior High School, Williams Middle School, and the Mary C. Burke School.	Effective.	Mobile Generator Purchased in 2016 with Homeland Security Grant Install solar powered batteries at City Hall, and Police Station. Install battery at multiple city owned buildings and TND property for microgrid.
Participation in the Mystic Region Emergency Planning Committee	City-wide.	A forum for cooperation on natural and manmade disasters.	Continued Activity and Participation in Mystic Region Emergency Planning Committee
FLOOD HAZARDS			
Participation in the National Flood Insurance Program (NFIP)	Areas identified on the FIRM maps.	There are 240policies in force.	Encourage all homeowners to obtain insurance. Follow up on grant request to develop and implement Community Rating System in Chelsea.

Mitigation Measure	Area Covered	Effectiveness	Updates for 2022 Changes Needed ?
Capital Improvements Program	City-wide.	The City has made extensive drainage infrastructure upgrades under its Capital Improvements Program	• Willow and Central Ave Infrastructure Improvement project will redirect storm water flowing Willow Street onto Central Ave. • Island End River design underway • Beacham Street project installed new drainage system to capture and covey runoff.
City Engineering Dept. inspects all streets and drainage systems once construction is completed.	City-wide	Effective	DPW/WSD to perform this with under WSD Asset Management plan moving forward.
Public Works Operations/Maintenance	City-wide	Effective	Public Works completes annual MS4 Permit tasks. Up to date on current EPA requirements.
2010- 2017 Open Space Plan	City-wide	Effective	Updated Open Space and Recreation Plan adopted for 2017-24. Renovation of four open spaces to include urban heat mitigation features for residents, design for Island End River Park to be more resilient to coastal flooding and to provide additional urban heat mitigation factors
Flood Plain District	City -wide	Effective	Looking to implement CRS through the North Suffolk Regional Sustainability Office.
Flood related building restrictions.	Zoning Districts	Effective	None
Wetland Ordinance	City-wide	Effective	None

Mitigation Measure	Area Covered	Effectiveness	Updates for 2022 Changes Needed ?
Stormwater Management and Construction Site Management Ordinance	City-wide	Effective for new construction and reconstruction.	Public Works updated City Stormwater Ordinance to meet MS4 Permit compliance in 2020.
Subdivision Rules and Regulations	City-wide	Somewhat Effective	None
DAM HAZARDS			
DCR Dam Safety	N/A: No dams in Chelsea	N/A	N/A
EXTREME HEAT HAZARDS			
The City maintains a link on its City web page to the Center for Disease Control web page on actions on how to prevent overheating	City-wide.	Effective.	City has collected ongoing data on internal (building) and external (built environment) urban heat index parameters. The City is implementing urban heat mitigation techniques via heat pumps, AC units, increased tree canopy, and increased heat resilience via splash features and shade structures
WIND HAZARDS			
CEMP	City-wide	Effective	Update of CEMP In process, Estimated complete July 2022.
The Massachusetts State Building Code	City-wide	Effective for most situations except severe storms.	None
Tree trimming program and power line corridor maintenance.	City-wide	Satisfactory	Consider underground lines for critical corridors; consider enhanced tree trimming DPW to continue citywide evaluation to locate problem trees.
Backup generator capacity in place at key public facilities.	City-wide	Effective	Install solar powered batteries at City Hall, and Police Station. Install battery at multiple city owned buildings and TND property for microgrid.

Mitigation Measure	Area Covered	Effectiveness	Updates for 2022 Changes Needed ?
WINTER HAZARDS			
Snow Removal	City-wide	Effective	None
Snow disposal	The City uses Parcel 12A for snow disposal.	Effective	Snow disposal site located at 295 Eastern Avenue.
Snow and ice control plans	The City has a program to notify citizens of snow emergencies.	Effective	City uses Reverse 911 and Social Media to notify citizens of snow emergencies.
GEOLOGIC HAZARDS			
The Massachusetts State Building Code	City-wide	Effective	None
Mobile generators and light pole for power/light backup	City-wide	Effective	Mobile Generator Purchased in 2016 with Homeland Security Grant
Under drains installed at Powder Horn Hill	The City has installed under drains in Powder Horn Hill to relieve water seepage.	Somewhat effective	City is reviewing and restoring areas where retaining walls are at risk of being undermined. Also concern that increased precipitation and freeze/thaw may have impact.
BRUSH FIRE HAZARDS			
Outdoor burning not allowed.	City-wide	Effective	No change
Water availability: 100 % of City is served by hydrants.	City-wide	Effective	No change
The Fire Dept reviews development projects to ensure that fire safety	City-wide	Effective.	No change
MetroFire mutual aid.	City-wide	Effective.	No changes
Public Education	City-wide	Effective.	No changes

MITIGATION CAPABILITIES AND LOCAL CAPACITY FOR IMPLEMENTATION

Under the Massachusetts system of "Home Rule," the City of Chelsea is authorized to adopt and from time to time amend local ordinances and regulations that support the city's capabilities to mitigate natural hazards. These include Zoning Ordinances, Subdivision and Site Plan Review Regulations, Wetlands Ordinance, Health Regulations, Public Works regulations, and local enforcement of the State Building Code. Local Ordinances may be amended by the City Council to improve the city's capabilities, and changes to most regulations simply require a public hearing and a vote of the authorized board or commission. The City of Chelsea has recognized several existing mitigation measures that require implementation or improvements and has the capacity within its local boards and departments to address these.

The City can improve its hazard mitigation capabilities with the following measures:

• Review and update the Low Impact Development best practices in the Town's LID guidelines and consider incorporating LID requirements more formally into a bylaw to ensure it becomes widely adopted in new developments and redevelopments.

• The City can update the Floodplain Ordinance to incorporate the next edition of the Flood Insurance Rate Maps, which are expected to be released by FEMA in 2022.

• The City can consider participating in the Community Rating System to enhance its mitigation capabilities while provide reduced flood insurance rates to residents and businesses.

• When preparing the City's next Master Plan, incorporate Hazard Mitigation and Climate Resilience as a formal component of the plan, equivalent to other components traditionally included in a Master Plan such as Land Use, Transportation, Housing, and Economic Development.

• When preparing the City's next Open Space and Recreation plan, incorporate Hazard Mitigation and Climate Resilience as a formal component of the plan. Identify opportunities for open space protection and land acquisition that would have specific hazard mitigation co-benefits, such as managing stormwater to reduce flooding, protecting vegetation for shade to mitigate extreme heat, and managing wetlands and tree canopy to mitigate climate impacts.

• Expand the City's tree trimming operations, in coordination with the utilities, to reduce vulnerability to high winds and winter storms and the City's risk of power outages.

• In reviewing and permitting new development projects, refer to the Hazard Mitigation Plan for guidance to incorporate mitigation into site design and construction.

• Review and update the Town's water conservation plan to enable a more robust mitigation of drought, which has occurred more frequently in the last decade and is projected to increase in the future due to climate change.

• Take advantage of opportunities to collaborate on regional mitigation issues Continue to collaborate with the City of Everett on improvements in the Island End River area of both cities. Regularly coordinate with the Metro Mayors Climate Task Force and the Resilient Mystic Collaborative to work with neighboring cities and state agencies such as DCR to address issues beyond the borders of the City that could impact Chelsea

• Financing the implementation of mitigation measures: the City can incorporate a program of its highest priority mitigation measures into its Capital Investment Program to ensure that these receive priority along with other categories of municipal investment such as roadways and municipal buildings.

SECTION 7: MITIGATION MEASURES FROM PREVIOUS PLAN

IMPLEMENTATION PROGRESS ON THE PREVIOUS PLAN

At a meeting of the Chelsea Hazard Mitigation Team, City staff reviewed the mitigation measures identified in the 2017 Chelsea Hazard Mitigation Plan and determined whether each measure had been completed, partially completed, revised, or not completed. Of those measures that had not been completed, the Team evaluated whether the measure should be deleted or carried forward into this Hazard Mitigation Plan 2022 Update. The decision on whether to delete or retain a particular measure was based on the team's assessment of the continued relevance or effectiveness of the measure. Table 42 summarizes the current status of mitigation measures from the 2016 plan.

Table 42 – Status of Recommended Mitigation Measures from the 2017 Plan

Mitigation Measure	Description	Current Status 2022 • Completed • Partially Completed • Not Completed	Retain in 2022 Plan? • YES • YES, REVISE • NO
FLOODNG HAZARDS			
A. Spruce and Blossom Streets drainage	Complete Spruce and Blossom Streets drainage projects to mitigate flooding.	Partially Completed	**YES**
B. Spruce Street drain and CSO separation	Mitigate flooding by installing new drain under Spruce Street and completing CSO separation.	Partially Complete	**YES**
C. Island End culvert	Mitigate flooding caused by collapse of Island End culvert: Design and install new 11 x 9-foot culvert.	Partially complete In design/funding phase	**YES, REVISE** Include full Island End Project (BRIC grant)

Mitigation Measure	Description	Current Status 2022 • Completed • Partially Completed • Not Completed	Retain in 2022 Plan? • YES • YES, REVISE • NO
D. Willow Street pump station and Green Infrastructure	Mitigate flooding along Willow Street between Coynes and Maverick Streets by installing new pump station and Green Infrastructure Best Management Practices.	Partially Complete; Willow St Sewer Separation and Flood Mitigation Preliminary Design completed 2020	**YES**
E. Eastern Avenue Green Infrastructure	Mitigate flooding along Eastern Avenue near Webster Street by installing Green Infrastructure Best Management Practices.	Partially complete planning for Eastern Ave. Corridor, 2 vulnerable zones conducted, 2017 report	**YES**
F. Broadway, Market Street, Carter Street drainage system improvements	Continue to upgrade drainage and reduce flooding by implementing CIP system and drainage improvements, including the separation of stormwater drainage from the sanitary sewer system reduce or eliminate associated backflow and flooding during high water run-off periods. The improvements to the drainage system will reduce the frequency and depth of flooding in low-lying areas Projects will include drainage improvements for Broadway, designing work to replace the Market Street culvert, and rehabilitation of the Carter Street stormwater pump.	Partially complete	**YES**
G. Stormwater regulation for MS4 Permit	Develop and implement post-construction stormwater zoning practices that would satisfy the issuance of the anticipated MS4 stormwater permit.	Completed	**NO**
H. Floodplain and Conservation regulations	Upgrade floodplain zoning and conservation regulations and update as needed to be consistent with FEMA guidelines, as a minimum.	In progress City is reviewing sample ordinance for floodplain district	**YES**

Mitigation Measure	Description	Current Status 2022 • Completed • Partially Completed • Not Completed	Retain in 2022 Plan? • YES • YES, REVISE • NO
I. Waterfront flooding assessment	Assess Chelsea waterfront for additional sea and flood wall protection. This will include assessment of areas prone to flood during high tides and grant funding sources:	Completed	**NO**
J. Enforcement of flood proofing standards	Develop guidelines and prioritization for better enforcement of flood proofing standards.	Not completed; Revise	**YES, REVISE** Improve the City's BCGES Score (current score is 4)
K. Emergency Operations Planning for storms and flooding	Review emergency operation planning for storms and flooding.	Partially complete; City is currently updating the CEMP	**NO**
WIND HAZARDS			
L. Reinforce new masonry chimneys	Change the City Ordinances to require new masonry chimneys greater than six feet above a roof to have continuous steel bracing.	Not Completed	**NO**
M. Inventory public buildings and critical infrastructure	Create a prioritized inventory of public buildings and critical structures for potential to withstand high winds; retrofit to greatest degree possible.	Not Completed; Revise for 2022	**YES, REVISE** Break in to 2 categories for Public Buildings and Infrastructure (includes communications and lines owned by utilities)

Mitigation Measure	Description	Current Status 2022 • Completed • Partially Completed • Not Completed	Retain in 2022 Plan? • YES • YES, REVISE • NO
WINTER HAZARDS			
N. Outreach to vulnerable populations	Organize outreach to vulnerable populations to help promote and access safe heating centers/emergency shelters.	OEM sends weather updates to all departments Revamped R-911 is activated by City Manager, Police, OEM	**YES, REVISE** Expand to cover extreme heat and other hazards
O. Snow removal and parking program	Institute a coordinated snow removal and parking program to maintain access to clear roads for emergency vehicles and evacuations.	Not Completed	**YES**
GEOLOGIC HAZARDS			
P. Map and assess seismic hazards	Map and assess city vulnerability to seismic hazards by: 1) developing an inventory of public and commercial buildings that may be particularly vulnerable to earthquake damage; 2) collecting geologic information on seismic sources, soil conditions, and related potential hazards;3) maintaining a database to track community vulnerability to earthquake risk; 4) using GIS to map hazard areas, at-risk structures, and associated hazards (e.g., liquefaction and landslides) to assess high-risk areas	Not Completed; Revise	**YES, REVISE** Assess vulnerability of retaining walls that are vulnerable to erosion and landslides
FIRE HAZARDS			
Q. Arson prevention	Wildland Fires and Urban Fires: Perform arson prevention cleanup activities in areas of abandoned or collapsed structures, trash or debris, areas of stored flammables and previous spills.	Partially completed; Revise	**YES, REVISE** Combine #R and #S and add Phragmites area along Miller Creek

Mitigation Measure	Description	Current Status 2022 • Completed • Partially Completed • Not Completed	Retain in 2022 Plan? • YES • YES, REVISE • NO
R. Public information, education, and partnerships	Major Urban and Wildland Fires: Increase major urban/wildfire awareness by: 1) Organizing a local fire department tour to show local elected officials and planners the most vulnerable areas of the community's wildland-urban interface and increase their understanding of risks; 2) working with insurance companies, utility providers, and others to include urban and wildfire safety information in materials provided to area residents; 3)developing partnerships with neighborhood groups, homeowners' associations, and others to conduct outreach activities; 4) using local fire departments to conduct education programs in schools; 5)informing the public about proper evacuation procedures.	Partially completed; Revise	
DROUGHT HAZARDS			
S. Landscape design	Encourage drought tolerant landscape design by using permeable pavement to reduce runoff and increase groundwater recharge.	Not completed; Revise	**YES, REVISE** add Drought tolerant landscape plantings
EXTREME HEAT HAZARDS			
T. Increased tree plantings	Update site design requirement to increase tree plantings near buildings, increase the percentage of trees used in parking areas, and along public ways.	Not completed; Revise	**YES, REVISE** Expand to include: Identify areas suitable for additional vegetative cover

Mitigation Measure	Description	Current Status 2022 • Completed • Partially Completed • Not Completed	Retain in 2022 Plan? • YES • YES, REVISE • NO
U. Cool roof design standards	Update site design requirements to include cool roofing products that reflect sunlight and heat away from a building.	Not completed, Revise	**YES, REVISE** Review Cambridge Green Building Code, building envelope quality
MULTI-HAZARDS			
V. Assess vulnerability of the electrical grid	Assess vulnerability of the electrical grid, particular major City distribution lines and substations to natural hazards likely to be increased by climate change.	Partially complete; Resilient Mystic Collaborative assessment; 3 zones identified; better platform for collaboration with utilities; intersects with microgrid project	**YES**
W. Hazard education and awareness	*(SEE REVISED MITIGATION BELOW)* Assess community risk by: 1) Providing information on all types of hazards, preparedness and mitigation measures, and responses during hazard events; 2) Annually hosting a public hazards workshop or exposition for all residents; 3) Enhancing hazard awareness of the private sector, particularly lenders, insurance agents and realtors. *REVISED MITIGATION:* Promote community-based emergency preparedness by: 1) Working with community-based organizations and entities to develop a community-based emergency preparedness program 2) Developing a communications plan, in collaboration with community partners, to inform residents about types of hazards, preparedness and mitigation measures, and responses during hazard events, prioritizing communications to demographic groups that may not receive traditional City communications.	Partially Complete; Revise	**YES, RESIVE** (see revised language)

As indicated in Table 42, Chelsea made progress implementing several mitigation measures identified in the 2017 Hazard Mitigation Plan. The City adopted a new Stormwater Ordinance in 2020 and completed an assessment of the Chelsea waterfront for additional sea and flood wall protection in 2017. The City has begun work and partially completed several large, long term infrastructure projects, including Spruce and Blossom Streets drainage improvements; Spruce Street CSO separation, Island End culvert and drainage, Willow Street pump station and Green Infrastructure, Eastern Avenue Green Infrastructure, and Broadway, Market Street, Carter Street drainage system improvements.

The City also reevaluated mitigation measures which had not been completed and took the opportunity to revise most of them to meet current needs and carry the revised measures forward into this 2022 updated plan. Revised measures include the Island End River mitigation project, building guidelines to increase the City's BCGES score, expand outreach to vulnerable populations to include extreme heat and other hazards, inventory facilities in two categories, public buildings and infrastructure (includes communications and lines owned by utilities), revise seismic hazards to address vulnerability of retaining walls that are vulnerable to landslides; revise drought hazards to include drought tolerant landscape plantings; revise extreme heat hazards to identify areas suitable for additional vegetative cover and to review the Cambridge Green Building Code on building envelope quality; and revise hazard awareness and education to include working with community-based organizations to develop a community-based emergency preparedness program and developing a communications plan, prioritizing communications to demographic groups that may not receive traditional City communications

The mitigation measures that are carried over into this 2022 updated plan include seven measures that were partially completed since the 2017 plan and ten measures that were not completed but revised for this updated plan.

Moving forward into the next five-year plan implementation period there will be many more opportunities to incorporate hazard mitigation into the City's decision-making processes. The challenges the city faces in implementing these measures are primarily due to limited funding and available staff time. This plan should help the city prioritize the best use of its limited resources for enhanced mitigation of natural hazards.

SECTION 8: HAZARD MITIGATION STRATEGY

WHAT IS HAZARD MITIGATION?

Hazard mitigation means to permanently reduce or alleviate the losses of life, injuries and property resulting from natural hazards through long-term strategies. These long-term strategies include planning, policy changes, education programs, infrastructure projects and other activities. FEMA currently has three mitigation grant programs: the Hazards Mitigation Grant Program (HMGP), the Building Resilient Infrastructure and Communities (BRIC) grant program, and the Flood Mitigation Assistance (FMA) program. The three links below provide additional information on these programs.

https://www.fema.gov/hazard-mitigation-grant-program
https://www.fema.gov/bric
https://www.fema.gov/flood-mitigation-assistance-grant-program

Hazard Mitigation Measures can generally be sorted into the following groups:

- Prevention: Government administrative or regulatory actions or processes that influence the way land and buildings are developed and built. These actions also include public activities to reduce hazard losses. Examples include planning and zoning, building codes, capital improvement programs, open space preservation, and stormwater management regulations.
    - Property Protection: Actions that involve the modification of existing buildings or infrastructure to protect them from a hazard or removal from the hazard area. Examples include acquisition, elevation, relocation, structural retrofits, flood proofing, storm shutters, and shatter resistant glass.
    - Public Education & Awareness: Actions to inform and educate citizens, elected officials, and property owners about the potential risks from hazards and potential ways to mitigate them. Such actions include outreach projects, real estate disclosure, hazard information centers, and school-age and adult education programs.
    - Natural Resource Protection: Actions that, in addition to minimizing hazard losses also preserve or restore the functions of natural systems. These actions include sediment and erosion control, stream corridor restoration, watershed management, forest and vegetation management, and wetland restoration and preservation.
    - Structural Projects: Actions that involve the construction of structures to reduce the impact of a hazard. Such structures include storm water controls (e.g., culverts), floodwalls, seawalls, retaining walls, and safe rooms.
    - Emergency Services Protection: Actions that will protect emergency services before, during, and immediately after an occurrence. Examples of these actions include protection of warning system capability, protection of critical facilities, and protection of emergency response infrastructure.
      (Source: FEMA Local Multi-Hazard Mitigation Planning Guidance)

NEW DEVELOPMENT AND INFRASTRUCTURE

As part of the process of developing recommendations for new mitigation measures for this plan update, the City considered the issues related to new development, redevelopment, and infrastructure needs in order reduce and limit future risks of natural hazards. Taking into consideration a host of measures to regulate new development and mitigate its impacts, including the city's Floodplain Overlay Zoning District enforced for new development, the Stormwater Management Ordinance requirements enforced for development by the Department of Public Works, the Building Code enforced for development by the Inspectional Services Division, the Wetlands Protection Act enforced for development by the Conservation Commission, the City's *Designing Coastal Community Infrastructure for Climate Change*, the Open Space and Recreation Plan, and the Lower Mystic Regional Climate Assessment, the City of Chelsea has determined that existing policies, planning, and regulatory measures are taking full advantage of local Home Rule land use regulatory authority to minimize natural hazard impacts of new development and redevelopment. As a mature city with older infrastructure, the major priorities that emerged for the City are strategic infrastructure upgrades in the most problematic areas. These upgrades will provide greater capacity to reduce hazard risks for both existing and new development as well as redevelopment in the City. This is the focus of several of this plan's recommended mitigation measures in the following section.

RECOMMENDED MITIGATION MEASURES

The recommended mitigation measures for this plan update are listed below and summarized in Table 43 (showing prioritization) and Table 44 (showing lead agencies, cost estimates, timelines, funding sources).

Of the 20 recommended mitigation measures listed, 16 will keep the same priorities assigned them in the 2017 plan (8 High, 7 Medium, and 1 Low priority). Four mitigation measures have changed priorities in this 2022 plan update. Outreach to vulnerable populations for extreme heat has been changed from medium to high, as has outreach for extreme cold. Assessment of critical infrastructure for vulnerability to wind hazards has bee changed from low to medium, as has assessment of public buildings. All of these changes reflect the City placing a higher priority of anticipated climate change impacts of heat and extreme weather.

The recommended mitigation measures below are grouped by their hazard categories, with several of them in a "multi-hazard" category.

FLOODING

A. **Spruce and Blossom Streets drainage**: Complete Spruce and Blossom Streets drainage projects to mitigate flooding.

B. **Spruce Street drain and CSO separation**: Install new drain under Spruce Street and complete CSO separation.

C. **Island End River culvert and flood protection project**: Mitigate flooding caused by collapse of Island End culvert: Design and install new 11 x 9-foot culvert.

D. **Willow Street pump station and Green Infrastructure**: Mitigate flooding along Willow Street between Coynes and Maverick Streets by installing new pump station and Green Infrastructure.

E. **Eastern Avenue Green Infrastructure**: Mitigate flooding along Eastern Avenue near Webster Street by installing Green Infrastructure.

F. **Broadway, Market Street, Carter Street drainage system improvements**: Upgrade drainage by implementing CIP drainage improvements, including separation of stormwater from the sanitary sewer to reduce or eliminate backflow and flooding during high run-off periods. Improvements to reduce frequency and depth of flooding. Projects include improvements for Broadway, design work to replace the Market Street culvert, and rehabilitation of the Carter Street stormwater pump.

G. **Floodplain and Conservation regulations**: Upgrade floodplain zoning and conservation regulations to be consistent with FEMA guidelines, as a minimum.

H. **Enforcement of flood proofing standards;** improve the City's BCGES score; develop guidelines and prioritization for better enforcement of flood proofing standards.

WIND HAZARDS

I. **Assess wind resilience of public buildings:** Inventory public buildings for potential to withstand high winds; retrofit to the degree feasible.

J. **Assess wind resilience of critical infrastructure** : Inventory critical infrastructure (includes communications and lines owned by utilities) for potential to withstand high winds; retrofit to the degree feasible.

WINTER HAZARDS

K. **Outreach to vulnerable populations**: Organize outreach to vulnerable populations to help promote and access safe heating centers/emergency shelters.

L. **Snow removal and parking program**: Implement a coordinated snow removal and parking program to maintain access for emergency vehicles and evacuations.

GEOLOGIC HAZARDS

M. **Map and assess seismic hazards**: Assess vulnerability of retaining walls that are susceptible to erosion and landslides. Focus on the Powder Horn Hill area.

FIRE HAZARDS

N. **Fire Prevention, public information, education, and partnerships**: Perform arson prevention cleanup activities in areas of abandoned structures, trash or debris, stored flammables, Phragmites area along Miller Creek. Increase wildfire awareness:

1) Organize a Fire Dept. tour to show local officials vulnerable areas of the City's wildland-urban interface and increase understanding of risks;
2) Work with insurance companies, utilities, and others to include fire safety information in materials provided to residents;
3) Develop partnerships with neighborhood groups to conduct outreach;
4) Conduct fire safety education programs in schools.

DROUGHT HAZARDS

O. **Landscape design and plantings:** Encourage drought tolerant plantings and landscape design by using permeable pavement to reduce runoff and increase groundwater recharge.

EXTREME HEAT HAZARDS

P. **Increased tree plantings**: Update site design requirement to increase tree plantings near buildings, increase the percentage of trees used in parking areas, and along public ways. Identify areas suitable for additional vegetative cover

Q. **Cool roof design standards**: Update site design requirements to include cool roofing products that reflect sunlight and heat away from a building. Review the Cambridge Green Building Code, building envelope quality.

R. **Outreach to vulnerable populations**: Organize outreach to vulnerable populations to help promote and access cooling resources.

MULITI-HAZARDS

S. **Assess vulnerability of the electric grid**: Assess vulnerability of the electrical grid, particular major City distribution lines and substations to natural hazards likely to be increased by climate change.

T. **Hazard education and awareness**: Promote community-based emergency preparedness:

1) Working with community-based organizations and entities to develop a community-based emergency preparedness program

2) Developing a communications plan, in collaboration with community partners, to inform residents about types of hazards, preparedness and mitigation measures, and responses during hazard events, prioritizing communications to demographic groups that may not receive traditional City communications.

PROCESS FOR SETTING PRIORITIES FOR MITIGATION MEASURES

The last step in developing the City's mitigation strategy is to assign a level of priority to each mitigation measure so as to guide the focus of the City's limited resources towards those actions with the greatest potential benefit. At this stage in the process, the Hazard Mitigation Team had limited access to detailed analyses of the cost and benefits of some mitigation measure, so prioritization is based on the local team members' understanding of existing and potential hazard impacts and an approximation of the range costs associated with pursuing those mitigation measure.

Priority setting was based on local knowledge of the hazard areas, including impacts of hazard events, the extent of the area impacted, and the relation of a given mitigation measure to the City's goals. Other factors considered included the number of homes and businesses affected, whether or not road closures occurred and what impact closures had on delivery of emergency services and the local economy, anticipated project costs, whether any environmental constraints existed, and whether the estimated costs could be justified relative to the anticipated benefits.

Table 43 demonstrates the prioritization of the City's potential hazard mitigation measures. For each mitigation measure, the geographic extent of the potential benefiting area is identified as is an estimate of the overall benefit and cost of the measures. The benefits, costs, and overall priority were evaluated in terms of:

stimated Benefits	
High	ction will result in a significant reduction of hazard risk to people and/or roperty from a hazard event
Medium	ction will likely result in a moderate reduction of hazard risk to people and/or roperty from a hazard event
Low	ction will result in a low reduction of hazard risk to people and/or property om a hazard event
stimated Costs	
High	timated costs greater than $250,000
Medium	timated costs between $100,000 to $250,000
Low	timated costs less than $100,000 and/or staff time
itigation Priority	
High	ction very likely to have political and public support and necessary aintenance can occur following the project, and the costs seem reasonable nsidering likely benefits from the measure
Medium	ction may have political and public support and necessary maintenance has otential to occur following the project
Low	ot clear if action has political and public support and not certain that ecessary maintenance can occur following the project

Table 43 –Recommended Chelsea Hazard Mitigation Measures

Mitigation Action	Geographic Extent Covered	Benefit Estimate	Cost Estimate	Priority
FLOOD HAZARDS				
A. Spruce and Blossom Streets drainage	Spruce Street and Blossom Street area	High	HIGH $1–2 M	High
B. Spruce Street drain and CSO separation	Spruce Street area	High	HIGH $2–3 M	High
C. Island End River culvert and flood protection project	Island End River area	High	HIGH $67.7 M	High
D. Willow Street pump station and Green Infrastructure	Willow Street between Coynes and Maverick Streets	High	HIGH $2–3 M	High
E. Eastern Avenue Green Infrastructure	Eastern Avenue near Webster Street	High	HIGH $5–6 M	High
F. Broadway, Market Street, Carter Street drainage system improvements	Broadway, Market Street, and Carter Street	High	HIGH TBD	High
G. Floodplain and Conservation regulations	City-wide	High	LOW $20,000 Staff Time	High
H. Enforcement of flood proofing standards; improve the City's BCGES score	City-wide	Medium	LOW $5,000 Staff Time	Medium
WIND HAZARDS				
I. Assess wind resilience of public buildings	City-wide	Low	MEDIUM $50,000 to assess; TBD Retrofit cost	Low
J. Assess wind resilience of critical infrastructure	City-wide	Medium	MEDIUM $50,000 to assess; TBD Retrofit cost	Medium

Mitigation Action	Geographic Extent Covered	Benefit Estimate	Cost Estimate	Priority
WINTER HAZARDS				
K. Outreach to vulnerable populations	City-wide	High	LOW $10,000/year Staff Time	High
L. Snow removal and parking program	City-wide	Medium	LOW $10,000/year Staff Time	Medium
GEOLOGIC HAZARDS				
M. Map and assess seismic hazards for retaining walls	Focus on Powder Horn Hill area	Medium	MEDIUM $50,000	Medium
FIRE HAZARDS				
N. Fire Prevention, public information, education, and partnerships	City-wide	Medium	LOW $5,000/year Staff time	Medium
0. Landscape design and plantings	City-wide	Low	LOW $1,000/year Staff time	Low
EXTREME HEAT HAZARDS				
P. Increased tree plantings	City-wide	Medium	LOW $10,000/ staff time	Medium
Q. Cool roof design standards	City-wide	Low	LOW $10,000/ staff time	Low
R. Outreach to vulnerable populations	City-wide	High	LOW $10,000/year Staff Time	High
MULITI-HAZARDS				
S. Assess vulnerability of the electric grid	City-wide	High	HIGH	High
T. Hazard education and awareness	City-wide	Medium	MEDIUM $50K--$250K	Medium

DESCRIPTION OF RECOMMENDED MITIGATION MEASURES

This plan's recommended mitigation measures are shown in Table 44, along with the following attributes for each recommended measure:

Mitigation Measure – A brief description of each mitigation measure is provided.

Priority – As described above and summarized in Table 40, the designation of high, medium, or low priority was done considering estimated potential benefits and estimated project costs, as well as other factors discussed by the local team in some cases.

Implementation Responsibility – The Hazard Mitigation Planning Team designated implementation responsibility by City agency staff and department managers. It is likely that some mitigation measures will require that several departments work together and assigning staff is the responsibility of the governing body of each community.

Time Frame – The time frame was based on a combination of the priority for that measure, the complexity of the measure and whether or not the measure is conceptual, in design, or already designed and awaiting funding. Funding opportunities could affect the time frame for implementation. Because the time frame for this plan is five years, the timing for mitigation measures is within this framework. The identification of a likely time frame is not meant to constrain a community from taking advantage of funding opportunities as they arise.

Estimated Cost - The cost data, if available, represent current rough estimates in most cases. When a cost estimate was not available, a range of costs was designated.

Potential Funding Sources – This column identifies likely sources of funding for each measure. Agencies with implementation responsibility in most cases will be responsible for pursuing funding opportunities. Funding sources may be internal or external to the City. Many measures may require several funding sources. Identification of a potential funding source does not guarantee that a project will be eligible for or selected for funding.

Additional information on funding sources – The best way to determine eligibility for a particular funding source is to review the project with a staff person at the funding agency. The following websites provide an overview of programs and funding sources.

Massachusetts Emergency Management Agency (MEMA) – The grants page https://www.mass.gov/hazard-mitigation-assistance-grant-programs describes the various Hazard Mitigation Assistance Program

Massachusetts Municipal Vulnerability Preparedness program offers annual Action Grants for implementation projects that increase community resilience to climate change and natural hazards. See https://www.mass.gov/service-details/mvp-action-grant

Army Corps of Engineers (ACOE) – The website for the North Atlantic district office is http://www.nae.usace.army.mil/. The ACOE provides assistance in a number of types of projects including flood damage reduction and flood plain management services.

Table 44 –Recommended Chelsea Hazard Mitigation Measures

Mitigation Action	Description	Lead Agency	Priority	Estimated Timeframe 2022-27	Estimated Cost	Potential Funding Sources
FLOOD HAZARDS						
A. Spruce and Blossom Streets drainage	Complete Spruce and Blossom Streets drainage projects to mitigate flooding.	Dept. of Public Works	High	2022-2024	**HIGH** **$1–2 M**	MassWorks / City of Chelsea General Fund
B. Spruce Street drain and CSO separation	Install new drain under Spruce Street and complete CSO separation.	Dept. of Public Works	High	2022-2024	**HIGH** $2–3 M	Development mitigation funds City of Chelsea General Fund
C. Island End River culvert and flood protection project	Mitigate flooding caused by collapse of Island End culvert: Design and install new culvert and construction of a flood barrier system and sluicegates at the Island End River area of the City of Chelsea and City of Everett	Dept of Housing and Community Development/ Dept. of Public Works	High	2022-2024	**HIGH** $67.7 M	FEMA BRIC grant/ City of Chelsea and City of Everett General Fund
D. Willow Street pump station and Green Infrastructure	Mitigate flooding along Willow Street between Coynes and Maverick Streets by installing new pump station and Green Infrastructure.	Dept. of Public Works	High	2022-2026	**HIGH** $2–3 M	City of Chelsea General Fund/ FEMA Grants
E. Eastern Avenue Green Infrastructure	Mitigate flooding along Eastern Avenue near Webster Street by installing Green Infrastructure.	Dept. of Public Works	High	2022-2025	**HIGH** $5–6 M	City of Chelsea General Fund/ FEMA Grants
F. Broadway, Market Street, Carter Street drainage system improvements	Upgrade drainage by implementing CIP drainage improvements, including separation of stormwater from the sanitary sewer to reduce or eliminate backflow and flooding during high run-off periods. Improvements to	Dept. of Public Works	High	2022-2027	**HIGH** TBD	City of Chelsea General Fund/ FEMA Grants

Mitigation Action	Description	Lead Agency	Priority	Estimated Timeframe 2022-27	Estimated Cost	Potential Funding Sources
	reduce frequency and depth of flooding. Projects include improvements for Broadway, design work to replace the Market Street culvert, and rehabilitation of the Carter Street stormwater pump.					
G. Floodplain and Conservation regulations	Upgrade floodplain zoning and conservation regulations to be consistent with FEMA sample ordinance.	Planning/ Conservation Commission	High	2022-2023	**LOW** $20,000 Staff Time	City of Chelsea General Fund
H. Enforcement of flood proofing standards; improve BCGES score	Develop guidelines for enforcement of flood proofing standards, improve BCGES score	Inspectional Services	Medium	2022-2027	**LOW** $5,000 Staff Time	City of Chelsea General Fund
WIND HAZARDS						
I. Assess wind resilience of public buildings	Inventory public buildings for potential to withstand high winds; retrofit to the degree feasible.	Inspectional Services	Low	2024-2025	**MEDIUM** $50,000 to assess; TBD Retrofit cost	City of Chelsea General Fund
J. Assess wind resilience of critical infrastructure	Inventory critical infrastructure (includes communications and lines owned by utilities) for potential to withstand high winds; retrofit to the degree feasible.	Emergency Management	Low	2024-2027	**MEDIUM** $50,000 to assess; TBD Retrofit cost	City of Chelsea General Fund
WINTER HAZARDS						
K. Outreach to vulnerable populations	Organize outreach to vulnerable populations to help promote and access safe heating centers/emergency shelters.	Emergency Management	Medium	2022-2027	**LOW** $10,000/year Staff Time	City of Chelsea General Fund
L. Snow removal and parking program	Implement a coordinated snow removal and parking program to maintain access for emergency vehicles and evacuations	DPW/Police MassDOT	Medium	2023-2025	**LOW** $10,000/year Staff Time	City of Chelsea General Fund / MassDOT

Mitigation Action	Description	Lead Agency	Priority	Estimated Timeframe 2022-27	Estimated Cost	Potential Funding Sources
GEOLOGIC HAZARDS						
M. Map and assess seismic hazards	Assess vulnerability of retaining walls that are susceptible to erosion and landslides; focus on the Powder Horn Hill area.	Planning/ Emergency Management	Medium	2023-2025	**MEDIUM** $50,000	City of Chelsea General Fund
FIRE HAZARDS						
N. Fire Prevention, public information, education, and partnerships	• Arson prevention cleanup activities in areas of abandoned structures, debris, stored flammables, Phragmites along Miller Creek. • Increase major urban/ wildfire awareness: 1) Organize a Fire Dept. tour to show local officials vulnerable areas of the City's wildland-urban interface and increase understanding of risks; 2) Work with insurance companies, utilities, and others to include fire safety information in materials provided to residents; 3) Develop partnerships with neighborhood groups to conduct outreach; 4) Conduct fire safety education programs in schools.	Fire Dept	Medium	2023-2026	**LOW** $5,000 per year / Staff time	City of Chelsea General Fund/ NFPA Grant
DROUGHT HAZARDS						
0. Landscape design and plantings	Encourage drought tolerant plantings and landscape design by using permeable pavement to reduce runoff and increase groundwater recharge.	Conservation Commission	Low	2023-2025	**LOW** $1,000/year Staff time	City of Chelsea General Fund
EXTREME HEAT HAZARDS						
P. Increased tree plantings	Update site design requirement to increase tree plantings near buildings, increase the percentage of trees used in parking areas, and along public ways. Identify areas suitable for additional vegetative cover	Planning	Medium	2022-2025	**LOW** $10,000 Staff time	City of Chelsea General Fund

Mitigation Action	Description	Lead Agency	Priority	Estimated Timeframe 2022-27	Estimated Cost	Potential Funding Sources
Q. Cool roof design standards	Update site design requirements to include cool roofing products that reflect sunlight and heat away from a building. Review the Cambridge Green Building Code, building envelope quality.	Planning	Medium	2022-2025	**LOW** $10,000/ staff time	City of Chelsea General Fund
R. Outreach to vulnerable populations	Organize outreach to vulnerable populations to help promote and access cooling resources		Medium	2022-2027	**LOW** $10,000/year Staff Time	City of Chelsea General Fund
MULITI-HAZARDS						
S. Assess vulnerability of the electric grid	Assess vulnerability of the electrical grid, particular major City distribution lines and substations to natural hazards likely to be increased by climate change. Implement Resilient Mystic Collaborative assessment; 3 zones identified; platform for collaboration with utilities (intersects with microgrid project)	Utilities/ Resilient Mystic Collaborative	High	2022-2024	**HIGH** TBD	Utilities/ Resilient Mystic Collaborative
T. Hazard education and awareness	Promote community-based emergency preparedness by: 1) Working with community-based organizations and entities to develop a community-based emergency preparedness program 2) Developing a communications plan, in collaboration with community partners, to inform residents about types of hazards, preparedness and mitigation measures, and responses during hazard events, prioritizing communications to demographic groups that may not receive traditional City communications.	EM/Planning	Medium	2022-2027	**LOW** $10,000 staff time	City of Chelsea General Fund? FEMA Grants/ Chamber of Commerce

REGIONAL AND INTER-COMMUNITY CONSIDERATIONS

Some hazard mitigation issues are strictly local. The problem originates primarily within the municipality and can be solved at the municipal level. Other issues are inter-community issues that involve cooperation between two or more municipalities. There is a third level of mitigation which is regional; involving a state, regional, or federal agency or an issue that involves numerous municipalities across a wide area of the metropolitan region.

Regional Partners

In many communities, mitigating natural hazards, particularly flooding, is more than a local issue. The drainage systems that serve these communities are a complex system of storm drains, roadway drainage structures, pump stations and other facilities owned and operated by a wide array of agencies including but not limited to the City of Chelsea, the Department of Conservation and Recreation (DCR), the Massachusetts Water Resources Authority (MWRA), and Massachusetts Department of Transportation (MA DOT). The planning, construction, operations, and maintenance of these structures are integral to the flood hazard mitigation efforts of communities. These agencies must be considered the City's regional partners in hazard mitigation. These agencies also operate under the same constraints as communities do, including budgetary and staffing constraints and numerous competing priorities. Implementation of regional mitigation measures will require that all parties work together to develop solutions.

Inter-Community Collaboration

Island End River- The Cities of Chelsea and Everett are collaborating to implement solutions for this critical area that impacts both communities. The two cities have prepared a mitigation project proposal that has been submitted to the Federal Emergency Management Agency for funding under the Building Resilient Infrastructure and Communities grant. The project description follows.

> Context: The Island End River is a tidally influenced waterway tributary to the Mystic River. The protected floodplain includes a district with regionally critical wholesale food processing, storage, and distribution industries. Moreover, a vulnerable cropping of fuel storage and energy assets, as well as critical state and local facilities including schools, hospitals, federal buildings, and state buildings exist within the impacting floodplain. Environmental Justice neighborhoods and critical regional transportation assets, including several FHWA Critical Urban Freight Corridors, Massachusetts Route 16, US Route 1, the MBTA Silverline Bus Station, and the MBTA Commuter Rail, are also located within the Island End River floodplain.
>
> Proposed project: The proposed mitigation project includes construction of a flood barrier system, culvert improvements, and sluicegates at the Island End River area of the City of Chelsea and City of Everett. The flood barrier includes a system of berms, floodwalls, and gates designed to protect the floodplain from coastal storm flowage in a projected 2070, 100-year (1% probability) flood event. The barrier will span over 3,500 linear feet and be constructed on coastal and inland spaces. The barrier is proposed to be built on lands owned by the respective cities or on lands subject to easement and land acquisition efforts, which

are presently under way at this time. As the region has a lack of public access to shoreline, the barrier system will include a public "riverwalk" to provide the public continuous access to the shoreline in all areas outside of the Designated Port Area limits, while adding new green recreational spaces for these environmental justice communities. Additionally, the program will restore salt marsh abutting the riverwalk to improve habitat and public enjoyment of the space. Salt marsh restoration will include phragmites removal and management, cleaning of trash and debris, and regionally appropriate salinity tolerant plantings.

Continuing along the banks of the Island End River adjacent to Market Street, the proposed flood barrier crosses the Chelsea/Everett city lines into Everett's Designated Port Area (DPA) where industrial users maintain active waterfront docks. By enhancing the existing well-maintained bulkheads and working with industrial property owners, this project can protect these facilities while maintaining their critical water-dependent operations. In Everett, the flood barrier then turns inland as a freestanding vertical flood wall that crosses roadway and rail rights-of-way and through easements across public property until it ties back to higher elevations along Beacham and Behen Streets. Crossings of roadways, rail lines, private driveways, and other curb cuts are achieved through flood gate systems that will be maintained and operated by the Cities of Chelsea and Everett. The Cities of Chelsea and Everett understand the key role that private property stakeholders play in the success of this regional flood protection system and are actively meeting with stakeholders through a monthly working group.

Culvert improvements will include replacement of 800 foot long and 10-foot by 15-foot, corrugated metal arch culvert extending from the end of the Island End River to inland drainage channels. The culvert is buried under a roadway designated a "critical urban freight corridor", which supports activities in the Lower Mystic Designated Port Area and carries flow from more than 250 acres of Everett's stormwater catchment area. The culvert pipe proposed for replacement has been subject to several catastrophic point failures in its over 50-year service life and it is considered a liability to freight operations on the roadway above. After years without maintenance by the private owners of the culvert pipeline the municipalities have taken ownership of the pipeline but have found it onerous to maintain due to extensive soil and groundwater contamination and dense land use above. The project proposes to replace 800 linear feet of culvert with new 12-foot by 16-foot box culvert.

New sluicegate systems will include controllable mechanical gates at the junction of the Island End River and the proposed flood barrier and culvert systems. The sluicegate system will unify flow from the new 12-foot by 16-foot culvert, a proximate 6-foot by 9-foot culvert, and several local collection pipes. The sluicegate system will be designed to pass flow to upstream tidal wetlands during typical conditions, but close ahead of exceptionally high water and storm surge events to protect inland areas from flooding and retain stormwater storage capacity. The sluicegate system will include provisions for flow conditioning, scour protection, access for maintenance, redundancy during service events, resilience in power and controls configuration, aesthetic integration with the wall and riverwalk, and prospective provision for future pumping system intake, should it be determined required at a later date.

Regional Collaboration

Chelsea is actively collaborating with surrounding communities, and regional organizations such as the Mystic River Watershed Association and the Metropolitan Area Planning Council on climate resiliency. The two most significant efforts are the Metro Mayors' Climate Preparedness Task force and the Resilient Mystic Collaborative, as summarized below:

Metro Mayors' Climate Preparedness Task Force

The task force was established in 2015 to provide a platform for regional coordination and integration of mitigation and resilience work across fourteen member communities in Greater Boston. Chelsea has benefitted from the region's commitment to climate action and the City makes every effort to ensure consistency with other climate change efforts throughout the region. Some of the main regional concerns include the following:

• The Amelia Earhart Dam is expected to be flanked on a regular basis during a 100-year storm event by 2035; by 2070 it will be overtopped during those events, assuming no additional improvement to its current structure or operations.

• Major regional transportation corridors, such as I-93 and Route 28, as well as the Orange line, Red line, and the Green Line Extension, are likely to experience significant impacts from coastal flooding, cutting off portions of the regional transportation system.

• Increased average temperatures combined with longer and more intense heat waves may increase electricity demand for cooling and could result in regional brown outs.

• Both the New England Produce Center (in Chelsea) and the Boston Market Terminal (in Everett) are highly vulnerable to coastal flooding; impacts to these facilities could pose serious threats to the availability of fresh food throughout the region.

Significant actions will be required by the State and Federal government, utilities, and other regional entities (such as ISO New England) to address certain infrastructure system vulnerabilities that are outside of Chelsea's direct control. The City can work with other impacted municipalities to become a powerful advocate for appropriate policies and projects to reduce regional vulnerabilities that impact Chelsea's residents and businesses.

Resilient Mystic Collaborative: Lower Mystic Regional Climate Assessment

This project was carried out by the cities of Boston, Chelsea, Everett, Revere, Somerville, and Winthrop, which are members Resilient Mystic Collaborative. The Mystic River Watershed Association and several Community Based Organizations and consultants assisted with the project. See the summary in Figure 29 below, and a description of the project in Section 6, Existing Mitigation Measures.

Figure 29: Summary of the Resilient Mystic Collaborative

About the Lower Mystic Watershed

Geographic Location

The Lower Mystic is defined as the saltwater portion of the Mystic River, extending from below the Amelia Earhart Dam to Deer Island. It includes the municipalities of Somerville, Everett, Chelsea, Boston (which includes the neighborhoods of Charlestown and East Boston), Winthrop, and Revere (Figure 1).

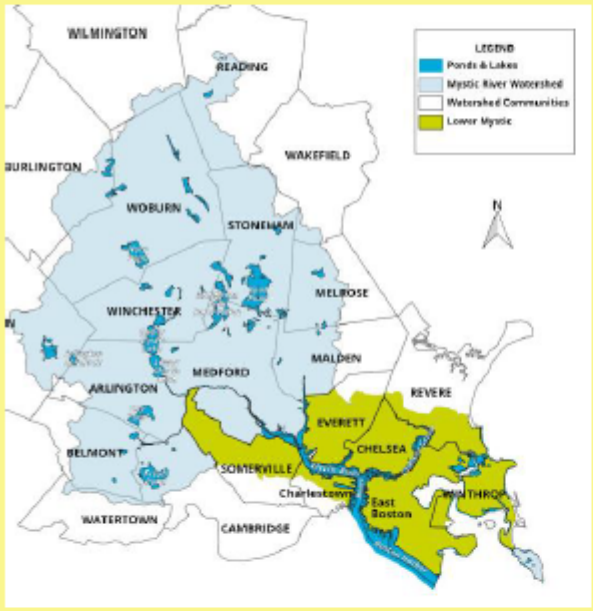


Figure 1. Location and extent of the Lower Mystic River Watershed (courtesy Mystic River Watershed Association).

Flooding in the Lower Mystic

Low lying areas throughout the Lower Mystic already flood in the present-day during astronomical high tides called King Tides. The frequency and intensity of flooding in the Lower Mystic is only expected to increase throughout the 21st century, posing increasing risk to both residents and the critical infrastructure on which they rely.

Resilient Mystic Collaborative

In September 2018, with generous support from the Barr Foundation, what became the Resilient Mystic Collaborative was launched with ten founding communities. Within 18 months, the RMC grew to 19 communities covering 95 % of the watershed, and raised over $1.7 million for regional climate resilience projects.

Today, the Resilient Mystic Collaborative (RMC) is a partnership among 20 neighboring communities in Greater Boston's Mystic River Watershed, founded out of a sense of urgency and commitment by municipal staff to work across boundaries to protect the region's people and places from climate-intensified risks.

Source: Lower Mystic Regional Climate Assessment, 2021

SECTION 9: PLAN ADOPTION & MAINTENANCE

PLAN ADOPTION

The *Chelsea Hazard Mitigation Plan 2022 Update* was adopted by the Chelsea City Council on [*ADD DATE*]. See Appendix D for documentation. The plan was approved by FEMA on [*ADD DATE*] for a five-year period that will expire on [*ADD DATE*].

PLAN MAINTENANCE

MAPC worked with the Chelsea Hazard Mitigation Team to prepare this plan. This group will continue to meet on an as-needed basis to coordinate the implementation and maintenance of this plan. A member of the City staff will be designated as the team coordinator. Additional members could be added to the local team from businesses, non-profits, and institutions. The city will encourage public participation during the next 5-year planning cycle. As updates and a review of the plan are conducted by the Hazard Mitigation Team, these will be placed on the City's web site, and any meetings of the Hazard Mitigation Team will be publicly noticed in accordance with city and state open meeting laws.

IMPLEMENTATION AND EVALUATION SCHEDULE

Mid-Term Survey on Progress – The coordinator of the Hazard Mitigation Team will prepare and distribute a survey in year three of the plan. The survey will be distributed to all the local team members and other interested local stakeholders. The survey will poll the members on progress and accomplishments for implementation, any new hazards or problem areas that have been identified, and any changes or revisions to the plan that may be needed.

This information will be used to prepare a report or addendum to the local hazard mitigation plan in order to evaluate its effectiveness in meeting the plan's goals and identify areas that need to be updated in the next plan. The Hazard Mitigation Implementation Team will have primary responsibility for tracking progress, evaluating, and updating the plan.

The City of Chelsea will work to integrate the content of the Hazard Mitigation Plan into other planning efforts including. This integration will enable more timely annual reports of mitigation action status.

Begin to Prepare for the next Plan Update – FEMA's approval of this plan is valid for five years, by which time an updated plan must be approved by FEMA in order to maintain the City's approved plan status and its eligibility for FEMA mitigation grants. Given the lead time needed to secure funding for planning and conduct the planning process, the Hazard Mitigation Team will begin to prepare for an update of the plan in year three. This will help the City avoid a lapse in its approved plan status and grant eligibility when the current plan expires.

The Hazard Mitigation Team will use the information from the Mid-Term progress review to identify the needs and priorities for the plan update and seek funding for the plan update process. Potential sources of funding may include FEMA Building Resilient Infrastructure and Communities (BRIC) grants and the Hazard Mitigation Grant Program. Both grant programs can pay for 75% of a planning project, with a 25% local cost share required.

Prepare and Adopt an Updated Local Hazard Mitigation Plan – Once the resources have been secured to update the plan, the Hazard Mitigation Team may decide to undertake the update themselves, contract with the Metropolitan Area Planning Council to update the plan or to hire another consultant to assist the City. However, if the Hazard Mitigation Team decides to update the plan, the city will need to review the current FEMA hazard mitigation plan guidelines for any changes in requirements for hazard mitigation plans since the previous plan. Once the next plan update is prepared, the City will submit it to MEMA and FEMA for review and approval and adopt the updated plan in order to obtain formal FEMA approval of the plan.

INTEGRATION OF THE PLANS WITH OTHER PLANNING INITIATIVES

Upon FEMA's approval of the Chelsea Hazard Mitigation Plan 2022, the Local Hazard Mitigation Team will provide all interested parties and implementing departments with a copy of the plan and will initiate a discussion regarding how the plan can be integrated into that department's ongoing work. Discussions will focus on how recommendations in the approved plan can be integrated into the City's capital improvement planning program, master plan, and other City process. Implementation of the plan will be reviewed with the following departments:

- Fire Department
- Emergency Management
- Police Department
- Department of Public Works
- Planning and Community Development
- Engineering
- Building
- Capital Projects
- Conservation Commission
- Parks and Recreation
- Health

Other groups that will be coordinated with include large institutions, Chambers of Commerce, Community Based Organizations, and the Mystic River Watershed Association. The plan will also be posted on the City's website. The posting of the plan on the website will include a mechanism for citizen feedback such as an e-mail address to send comments.

The City of Chelsea has taken steps to implement findings from the 2017 Hazard Mitigation Plan into the following policy, programmatic areas, and plans: the Capital Investment Plan, 2020-2024; Designing Coastal Community Infrastructure for Climate Change assessment (2017); amendments to the City's Stormwater Ordinance (2020); the Community Resilience Building (MVP) plan (2018); the Living with Heat plan (2019), and the Lower Mystic Regional Climate Plan (2021).

Other groups that will be coordinated with include large institutions, Chambers of Commerce, land conservation organizations and watershed groups. The plans will also be posted on a community's website with the caveat that local team coordinator will review the plan for sensitive information that would be inappropriate for public posting. The posting of the plan on a web site will include a mechanism for citizen feedback such as an e-mail address to send comments.

SECTION 10: LIST OF REFERENCES

City of Chelsea, *Designing Coastal Community Infrastructure for Climate Change*, 2017

City of Chelsea, *Beacham/Williams Street Corridor Study*, 2018

City of Chelsea, *Community Resilience Building Summary of Findings*, 2018

City of Chelsea, *Capital Improvement Plan*, 2020 to 2024

City of Chelsea, Code of Ordinances, Chapter 30, Article V, Sewers, and Storm Drains

City of Chelsea, *Equitable Climate Resiliency Framework Process Guide*, 2021

City of Chelsea, *Open Space and Recreation Plan*, 2017

City of Chelsea, *Proposed Chelsea Creek Municipal Harbor Plan,* 2021

City of Chelsea, *Willow Street Area Sewer Separation and Flood Mitigation Project*

City of Chelsea, Zoning Ordinance, Floodplain District

Blue Hill Observatory

FEMA, Flood Insurance Rate Maps for Suffolk County, MA, 2016

FEMA, Hazards U.S. Multi-Hazard (HAZUS-MH), 2021

FEMA, Local Mitigation Plan Review Guide, October 2011

FEMA. Local Multi-Hazard Mitigation Planning Handbook, 2013

Fourth National Climate Assessment, 2018

Massachusetts Drought Management Plan, 2019

Massachusetts Geographic Information System, 2016 Land Use maps

Massachusetts Office of Dam Safety, Inventory of Massachusetts Dams 2018

Massachusetts State Hazard Mitigation Plan, 2013

Massachusetts State Hazard Mitigation and Climate Adaptation Plan, 2018

National Weather Service

Nevada Seismological Library

New England Seismic Network, Boston College Weston Observatory

NOAA National Centers for Environmental Information

Northeast Climate Adaptation Science Center

Northeast States Emergency Consortium

Resilient Mystic Collaborative, Lower Mystic Regional Climate Assessment, 2021

Tornado History Project

Urban Land Institute, Living with Heat, Chelsea and Everett

US Census, 2020 and American Community Survey 2019, 5-Year Estimates

USGS, National Water Information System

APPENDIX A: HAZARD MAPPING

The MAPC GIS (Geographic Information Systems) Lab produced a series of maps for each community. Some of the data came from the Northeast States Emergency Consortium (NESEC). More information on NESEC can be found at http://www.serve.com/NESEC/. Due to the various sources for the data and varying levels of accuracy, the identification of an area as being in one of the hazard categories must be considered as a general classification that should always be supplemented with more local knowledge. The documentation for some of the hazard maps was incomplete as well.

The hazard series consists of eleven maps as follows:

Map 1.	Population Density
Map 2.	Potential Development
Map 3.	Flood Zones
Map 3A	Flood Claims for 2010 Storms
Map 4.	Earthquakes and Landslides
Map 5.	Hurricanes and Tornados
Map 6.	Average Snowfall
Map 7.	Composite Natural Hazards
Map 8.	Hazard Areas
Map 9	Hot Spots
Map 10	Sea Level Rise
Map 11	Coastal Flooding

Map 1: Population Density – This map uses the US Census block data for 2010 and shows population density as the number of people per acre in seven categories with 60 or more people per acre representing the highest density areas.

Map 2: Potential Development – This map shows potential future developments, and critical infrastructure sites. MAPC consulted with City staff to determine areas that were likely to be developed or redeveloped in the future.

Map 3: Flood Zones – The map of flood zones used the latest FEMA NFIP Flood Zones for Chelsea as its source. For more information, refer to the FEMA Map Service Center website http://www.msc.fema.gov. The definitions of the flood zones are described in detail on this site as well. The flood zone map for each community also shows critical infrastructure and municipally owned and protected open space.

Map 3A: Flood Claims, 2010 Storms – This map shows the flood assistance and flood insurance claims related to the major storms of 2010, categorized by depth of flooding.

Map 4: Earthquakes and Landslides – This information came from NESEC. For most communities, there was no data for earthquakes because only the epicenters of an earthquake are mapped.

The landslide information shows areas with either a low susceptibility or a moderate susceptibility to landslides based on mapping of geological formations. This mapping is highly general in nature. For more information on how landslide susceptibility was mapped, refer to http://pubs.usgs.gov/pp/p1183/pp1183.html.

Map 5: Hurricanes and Tornadoes – This map shows a number of different items. The map includes the storm tracks for both hurricanes and tropical storms. This information must be viewed in context. A storm track only shows where the eye of the storm passed through. In most cases, the effects of the wind and rain from these storms were felt in other communities even if the track was not within that community. This map also shows the location of tornadoes with a classification as to the level of damages. What appears on the map varies by community since not all communities experience the same wind-related events. These maps also show the 100-year wind speed.

Map 6: Average Snowfall - - This map shows the average snowfall and open space. It also shows storm tracks for nor'easters, if any storms tracked through the community.

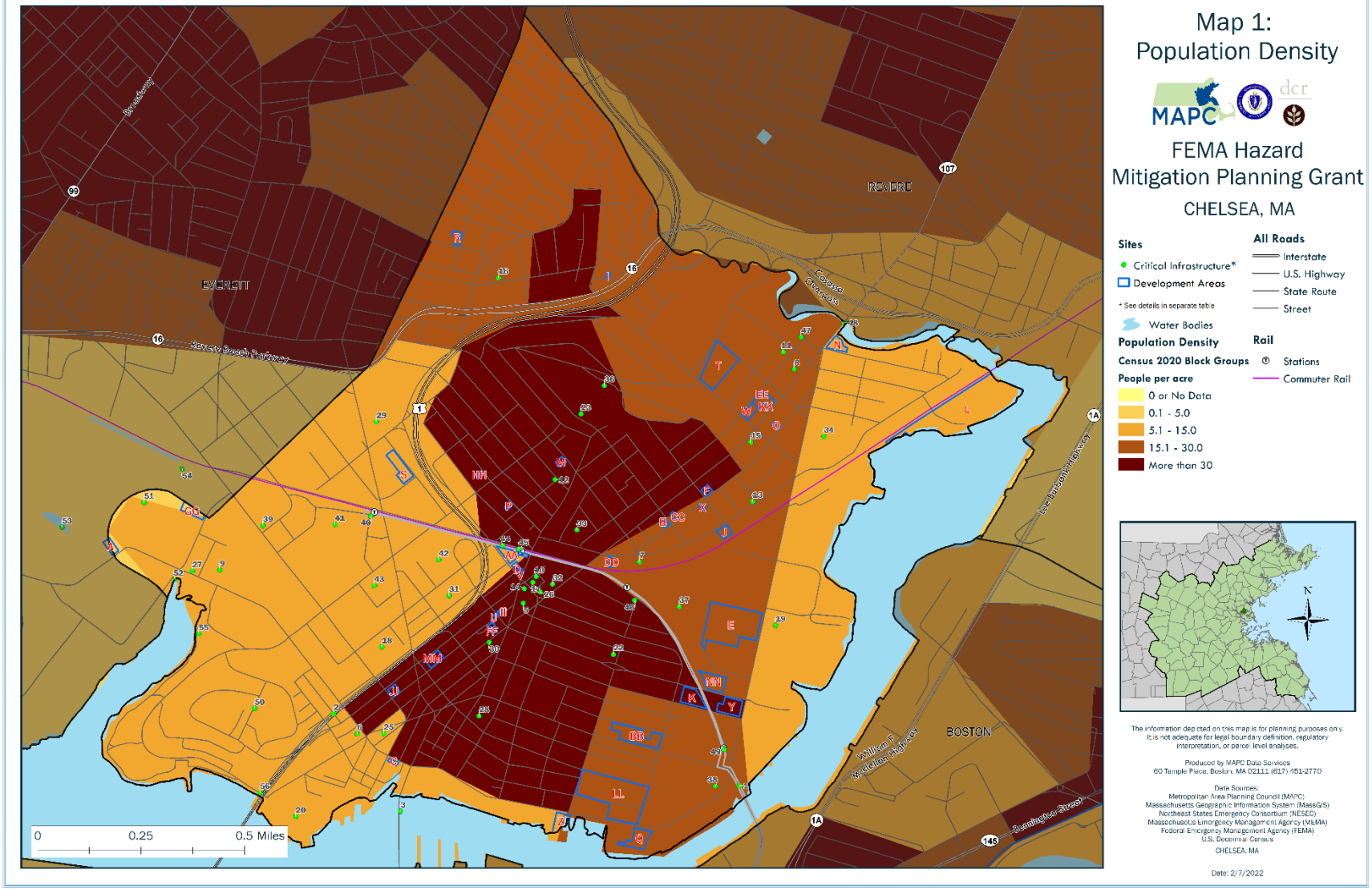
Map 7: Composite Natural Hazards - This map shows four categories of composite natural hazards for areas of existing development. The hazards included in this map are 100-year wind speeds of 110 mph or higher, low and moderate landslide risk, FEMA Q3 flood zones (100 year and 500 year) and hurricane surge inundation areas. Areas with only one hazard were considered to be low hazard areas. Moderate areas have two of the hazards present. High hazard areas have three hazards present and severe hazard areas have four hazards present.

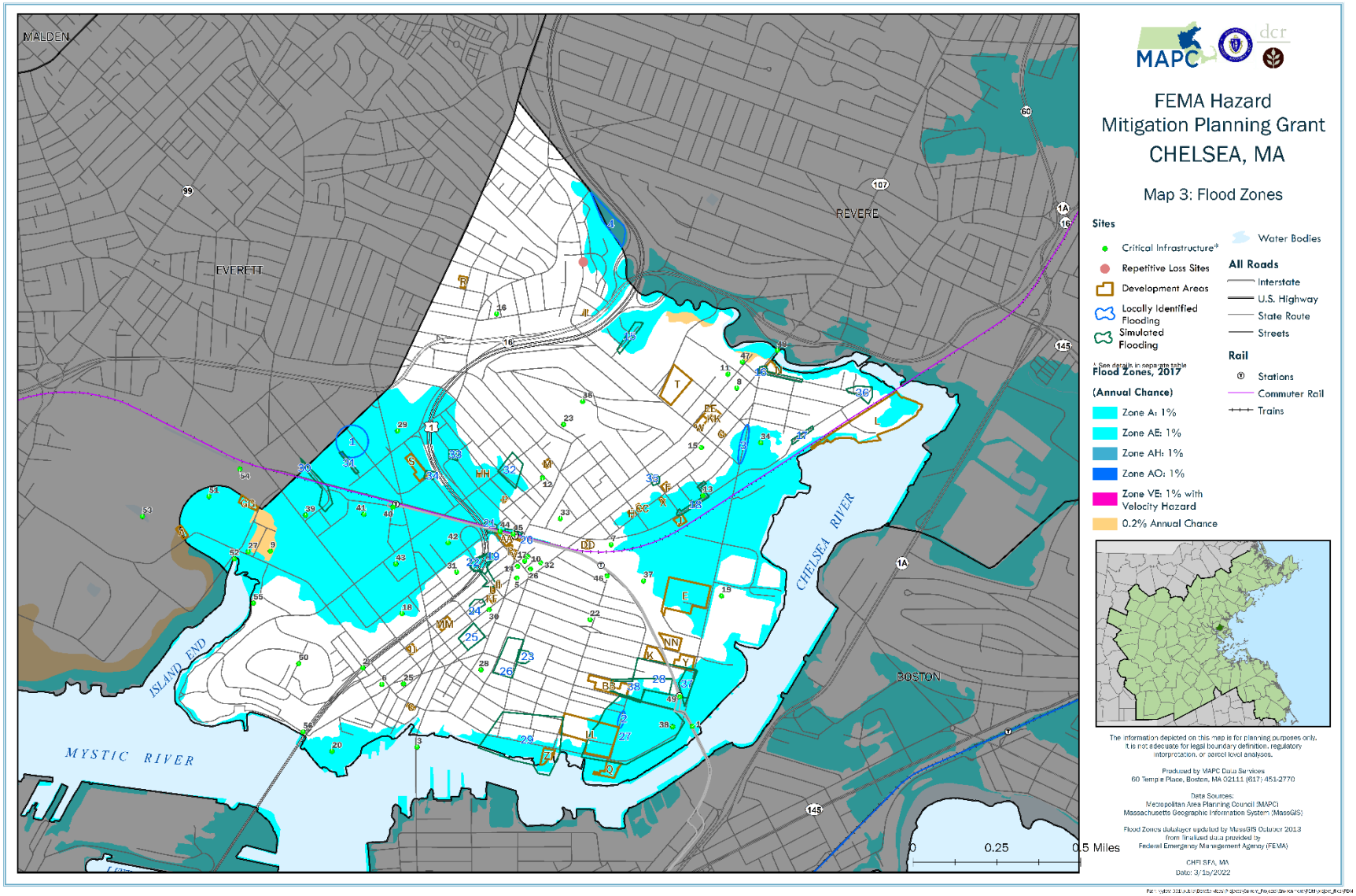
Map 8: Hazard Areas – For each community, locally identified hazard areas are overlaid on an aerial photograph dated April 2010. The critical infrastructure sites are also shown. The source of the aerial photograph is Mass GIS.

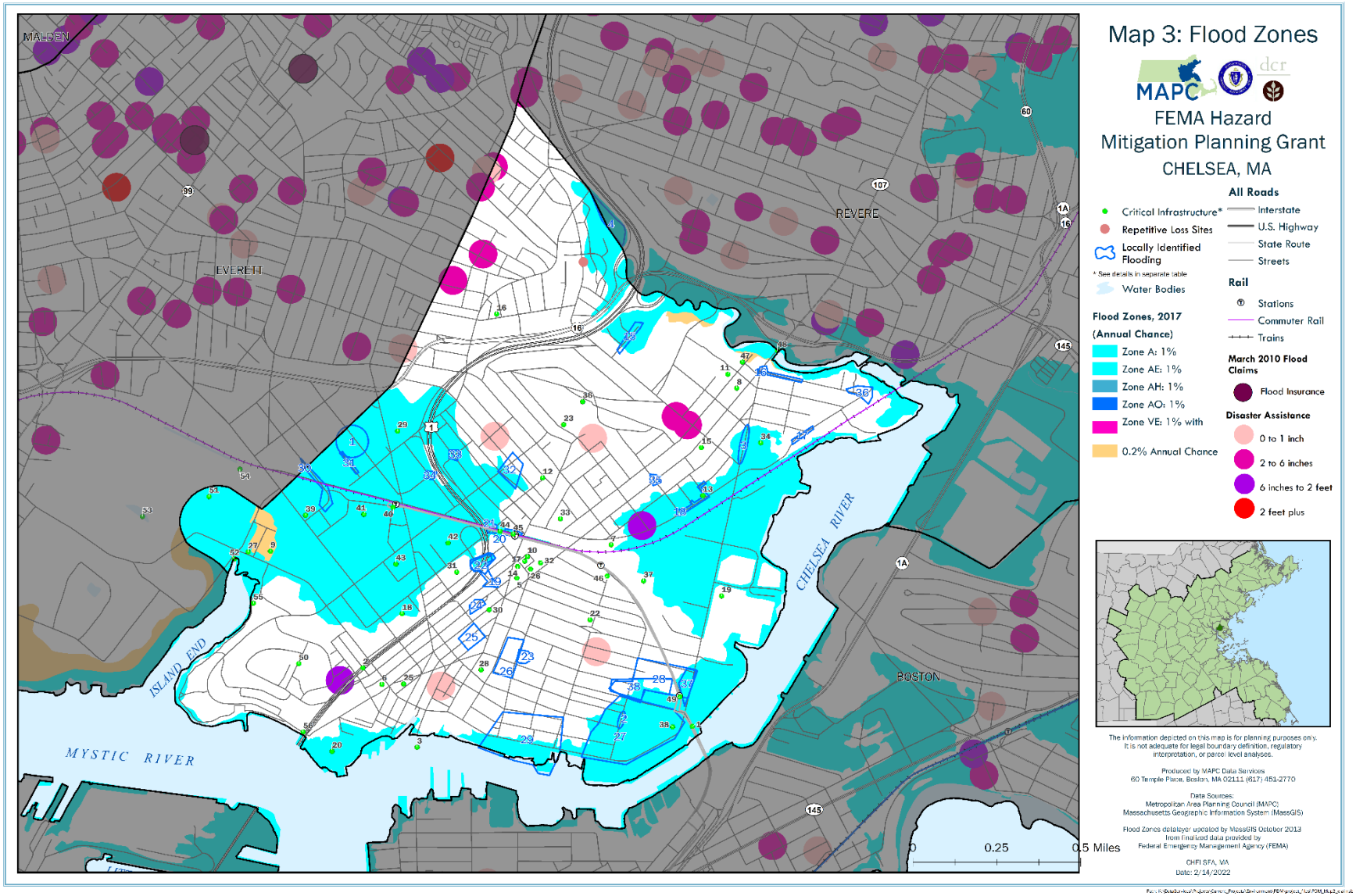
Map 9: Hot Spots: The hottest 5 percent land surface temperatures in the MAPC region based on infrared satellite imager from July 2015/

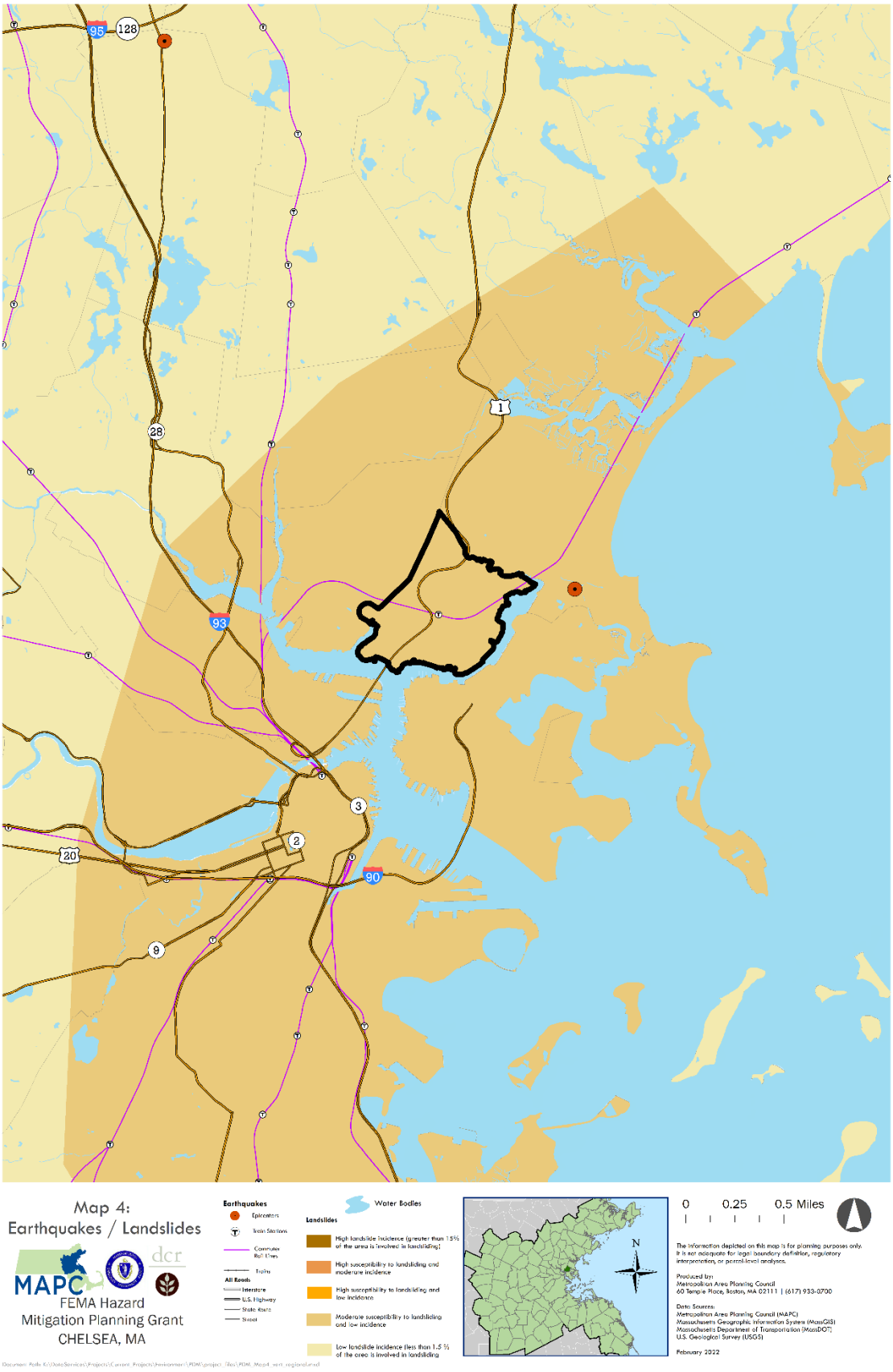
Map 10: Sea Level Rise: - Areas that would be inundated by four Sea Level Rise scenarios based on 1, 3. 6, and 10 feet of Sea Level Rise

Map 11: Coastal Flooding: - Annual chance of coastal flooding, present day scenario, based on the Massachusetts Coastal Resilience Model (MA-CRM) prepared by the Woods Hole Group for the Massachusetts Department of Transportation, 2021.


Map 1:
Population Density
MAPC
dcr
FEMA Hazard
Mitigation Planning Grant
CHELSEA, MA
Sites
Critical Infrastructure*
Development Areas
* See details in separate table
Water Bodies
Population Density
Census 2020 Block Groups
People per acre
0 or No Data
0.1 - 5.0
5.1 - 15.0
15.1 - 30.0
More than 30
All Roads
Interstate
U.S. Highway
State Route
Street
Rail
Stations
Commuter Rail
EVERETT
REVERE
BOSTON
0
0.25
0.5 Miles
The information depicted on this map is for planning purposes only. It is not adequate for legal boundary definition, regulatory interpretation, or parcel level analyses.
Produced by MAPC Data Services
60 Temple Place, Boston, MA 02111 (617) 451-2770
Data Sources:
Metropolitan Area Planning Council (MAPC)
Massachusetts Geographic Information System (MassGIS)
Northeast States Emergency Consortium (NESEC)
Massachusetts Emergency Management Agency (MEMA)
Federal Emergency Management Agency (FEMA)
U.S. Decennial Census
CHELSEA, MA
Date: 2/7/2022
Path: K:\DataServices\Projects\Current_Projects\Environment\PDM\project_files\PDM_Map1.mxd


MALDEN
EVERETT
REVERE
CHELSEA RIVER
ISLAND END
MYSTIC RIVER
BOSTON
0.25
0.5 Miles
MAPC
dcr
FEMA Hazard
Mitigation Planning Grant
CHELSEA, MA
Map 3: Flood Zones
Sites
Critical Infrastructure*
Repetitive Loss Sites
Development Areas
Locally Identified Flooding
Simulated Flooding
* See details in separate table
Flood Zones, 2017
(Annual Chance)
Zone A: 1%
Zone AE: 1%
Zone AH: 1%
Zone AO: 1%
Zone VE: 1% with Velocity Hazard
0.2% Annual Chance
Water Bodies
All Roads
Interstate
U.S. Highway
State Route
Streets
Rail
Stations
Commuter Rail
Trains
The information depicted on this map is for planning purposes only. It is not adequate for legal boundary definition, regulatory interpretation, or parcel level analyses.
Produced by MAPC Data Services
60 Temple Place, Boston, MA 02111 (617) 451-2770
Data Sources:
Metropolitan Area Planning Council (MAPC)
Massachusetts Geographic Information System (MassGIS)
Flood Zones dataLayer updated by MassGIS October 2013 from finalized data provided by Federal Emergency Management Agency (FEMA)
CHELSEA, MA
Date: 3/15/2022


Map 3: Flood Zones
MAPC
dcr
FEMA Hazard
Mitigation Planning Grant
CHELSEA, MA
MALDEN
EVERETT
REVERE
BOSTON
CHELSEA RIVER
ISLAND END
MYSTIC RIVER
Critical Infrastructure*
Repetitive Loss Sites
Locally Identified Flooding
* See details in separate table
Water Bodies
Flood Zones, 2017
(Annual Chance)
Zone A: 1%
Zone AE: 1%
Zone AH: 1%
Zone AO: 1%
Zone VE: 1% with
0.2% Annual Chance
All Roads
Interstate
U.S. Highway
State Route
Streets
Rail
Stations
Commuter Rail
Trains
March 2010 Flood Claims
Flood Insurance
Disaster Assistance
0 to 1 inch
2 to 6 inches
6 inches to 2 feet
2 feet plus
0
0.25
0.5 Miles
The information depicted on this map is for planning purposes only. It is not adequate for legal boundary definition, regulatory interpretation, or parcel level analyses.
Produced by MAPC Data Services
60 Temple Place, Boston, MA 02111 (617) 451-2770
Data Sources:
Metropolitan Area Planning Council (MAPC)
Massachusetts Geographic Information System (MassGIS)
Flood Zones dataLayer updated by MassGIS October 2013
from finalized data provided by
Federal Emergency Management Agency (FEMA)
CHFI SFA, MA
Date: 2/14/2022



Map 4:
Earthquakes / Landslides

MAPC

dcr

FEMA Hazard
Mitigation Planning Grant
CHELSEA, MA

Earthquakes
Epicenters
Train Stations
Commuter Rail Lines
Trains
All Roads
Interstate
U.S. Highway
State Route
Street

Water Bodies

Landslides
High landslide incidence (greater than 15% of the area is involved in landsliding)
High susceptibility to landsliding and moderate incidence
High susceptibility to landsliding and low incidence
Moderate susceptibility to landsliding and low incidence
Low landslide incidence (less than 1.5 % of the area is involved in landsliding

0 0.25 0.5 Miles

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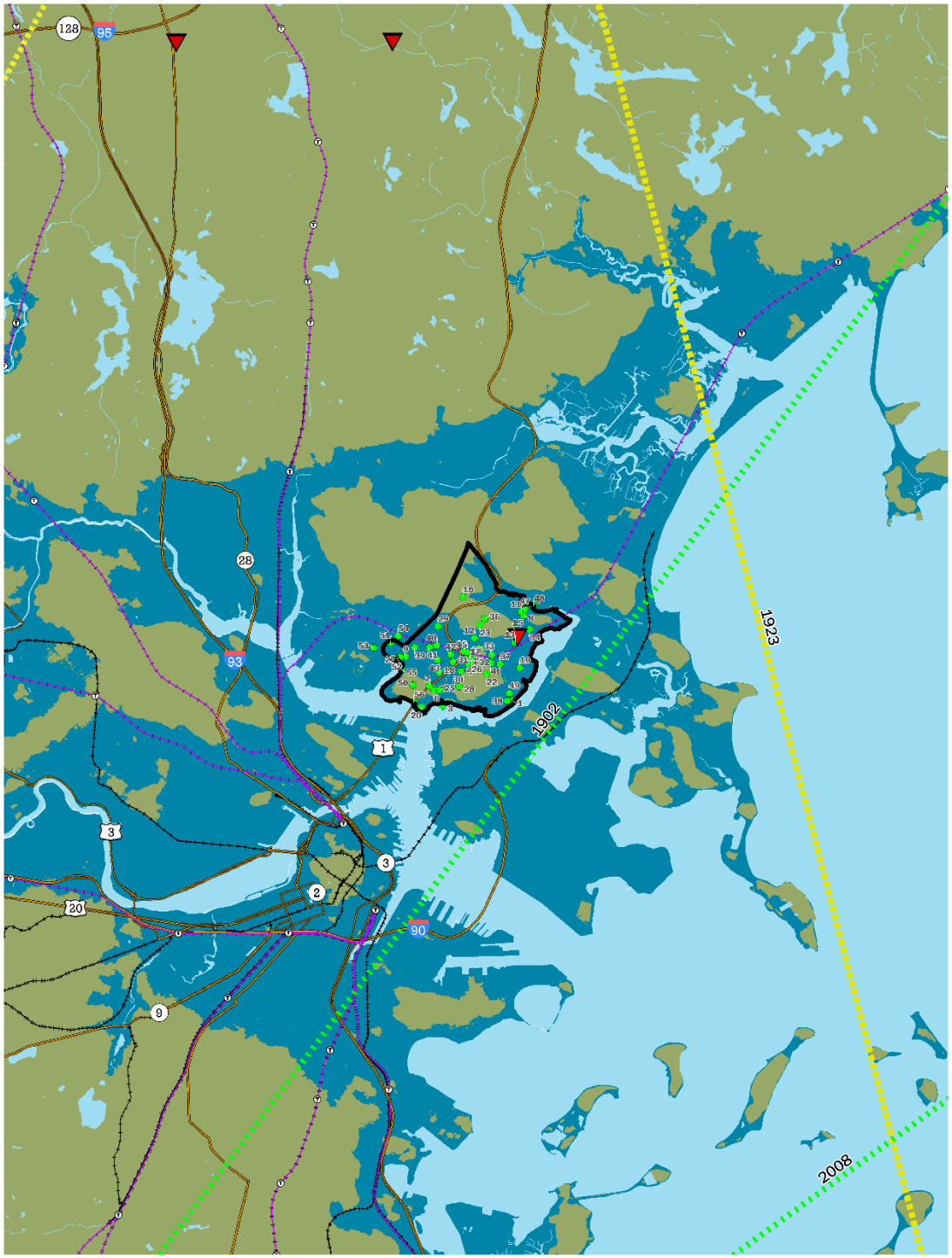
Produced by:
Metropolitan Area Planning Council
60 Temple Place, Boston, MA 02111 | (617) 933-0700

Data Sources:
Metropolitan Area Planning Council (MAPC)
Massachusetts Geographic Information System (MassGIS)
Massachusetts Department of Transportation (MassDOT)
U.S. Geological Survey (USGS)

February 2022



Map 5:
Hurricanes / Tornadoes

MAPC
dcr
FEMA Hazard
Mitigation Planning Grant
CHELSEA, MA

Tornadoes
Tornado
All Roads
Interstate
U.S. Highway
State Route
Street
Train Stations
Commuter Rail Lines
Trolins
Water Bodies
Critical Infrastructure Sites*
* See details in separate table

Storm Tracks
Tropical Depression
Tropical Storm
Category 1 Hurricane
Category 2 Hurricane
Category 3 Hurricane
Hurricane Surge Inundation Area
100 Year Wind Speeds Miles Per Hour
90 MPH
100 MPH
110 MPH
120 MPH
130 MPH

N

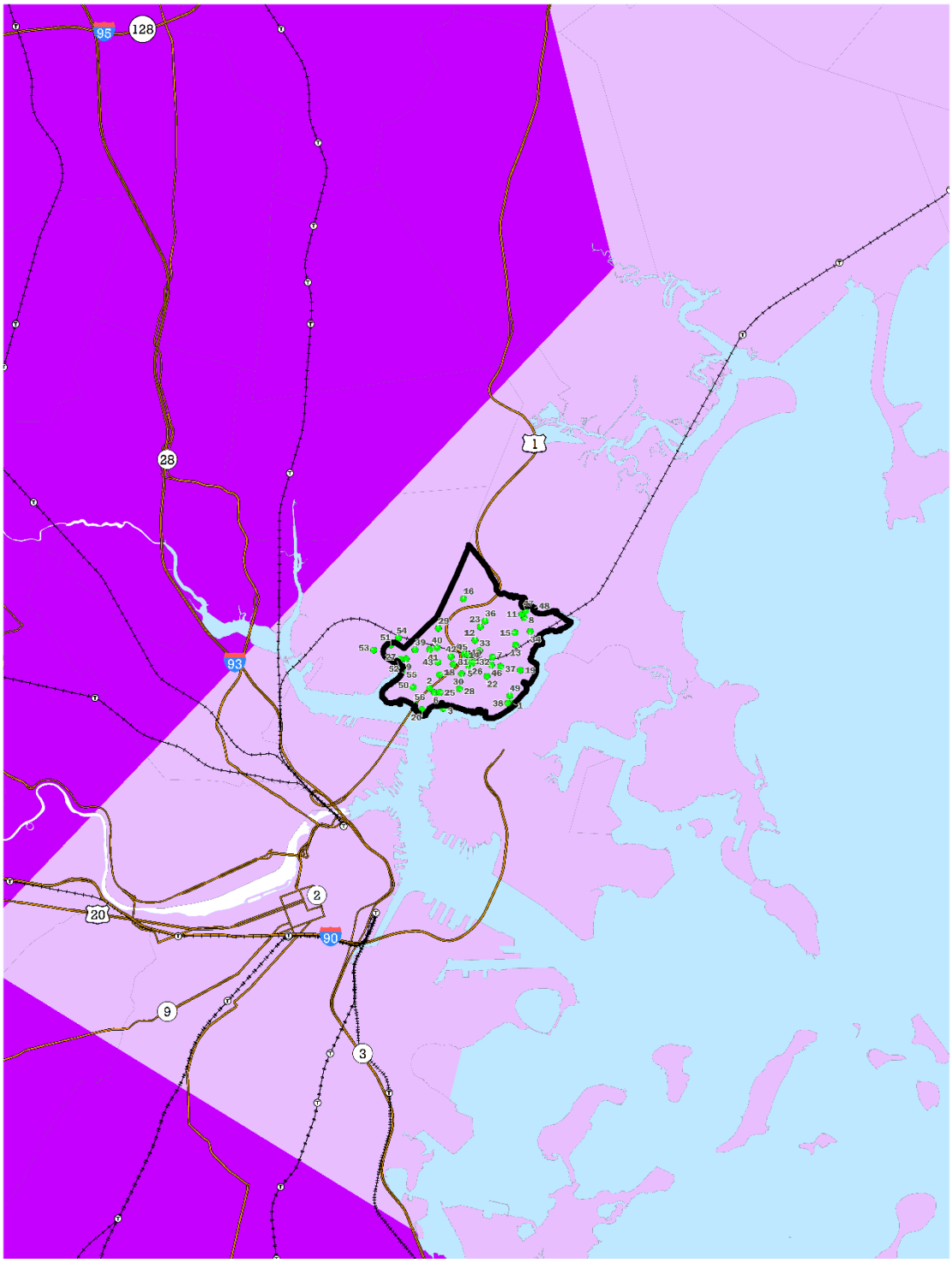
0 0.25 0.5 Miles

The information depicted on this map is for planning purposes only. It is not adequate for legal boundary definition, regulatory interpretation, or parcel-level analyses.

Produced by:
Metropolitan Area Planning Council
60 Temple Place, Boston, MA 02111 | (617) 933-0700

Data Sources:
Metropolitan Area Planning Council (MAPC)
Massachusetts Geographic Information System (MassGIS)
Massachusetts Department of Transportation (MassDOT)

February 2022



Map 6:
Average Snowfall

MAPC dcr

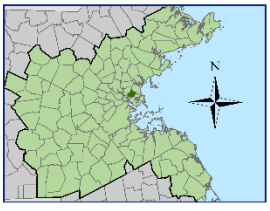
FEMA Hazard
Mitigation Planning Grant
CHELSEA, MA

Sites
- Critical Infrastructure Sites*
  * See details in seperate table

Average Annual Snowfall
- 36.1 to 48.0 inches
- 48.1 to 72.0 inches

- Water Bodies
- Train Stations
- Commuter Rail Lines
- Trains

All Roads
- Interstate
- U.S. Highway
- State Route
- Street



0 0.3 0.6 1.2 Miles

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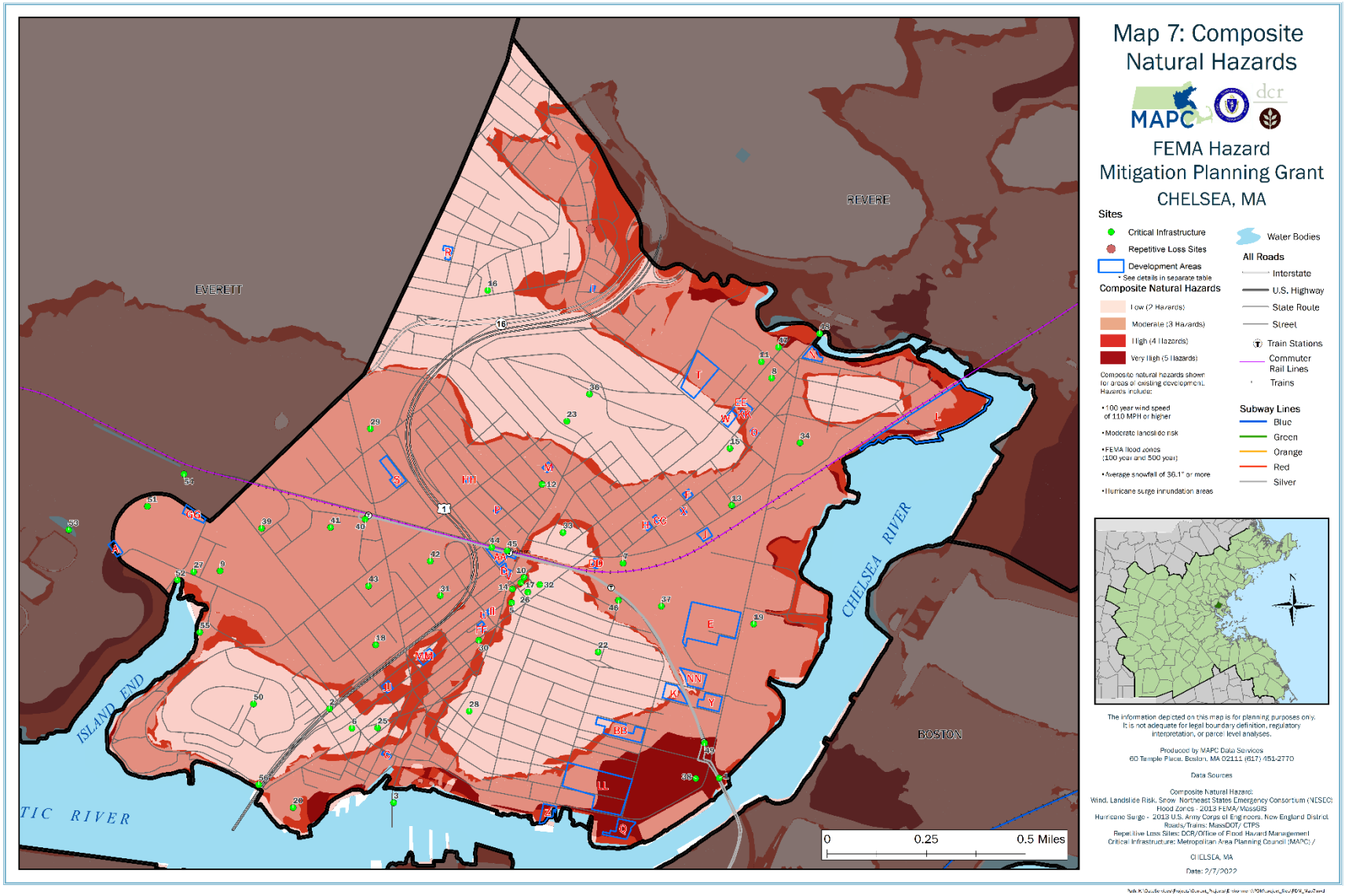
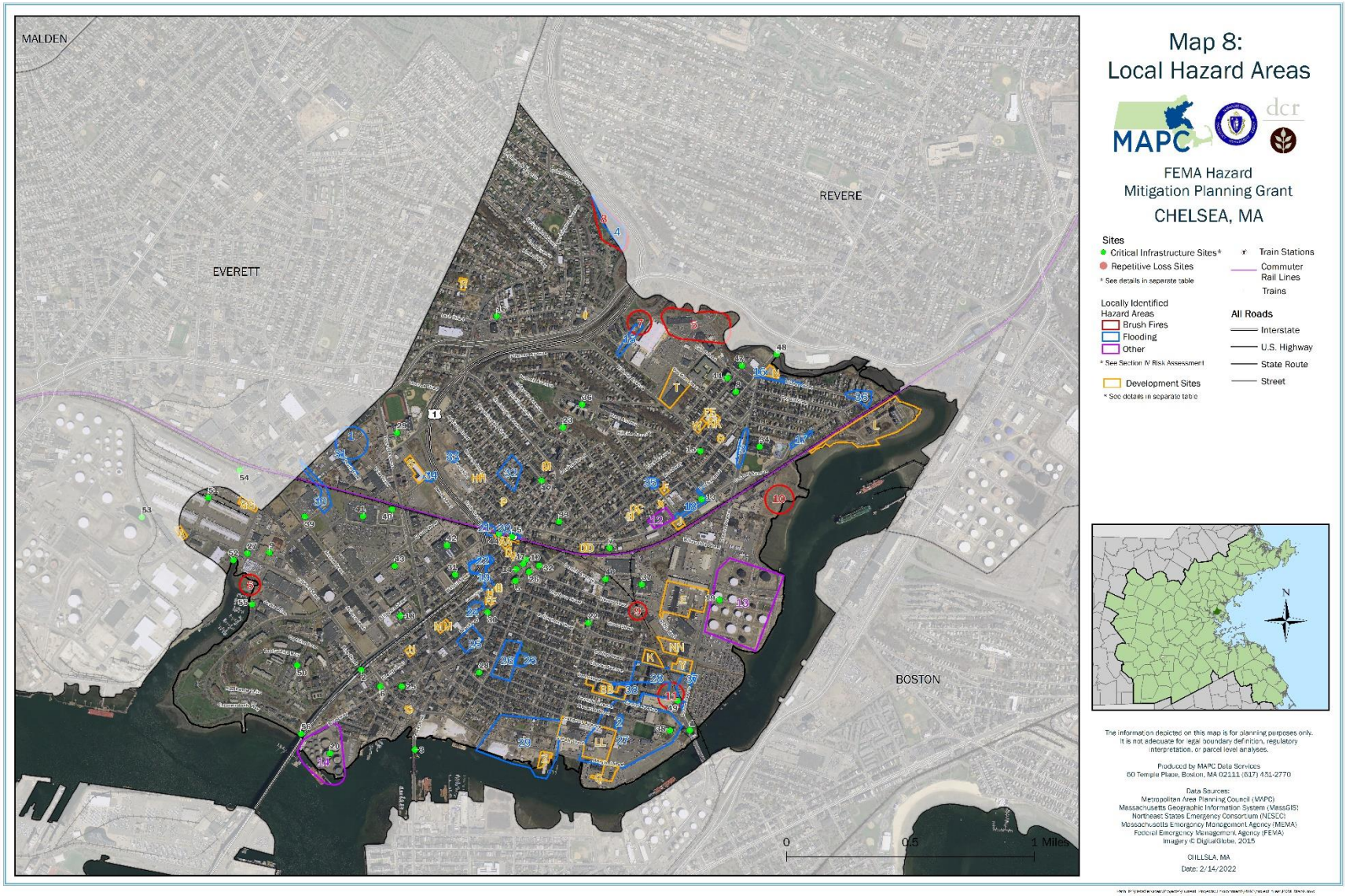
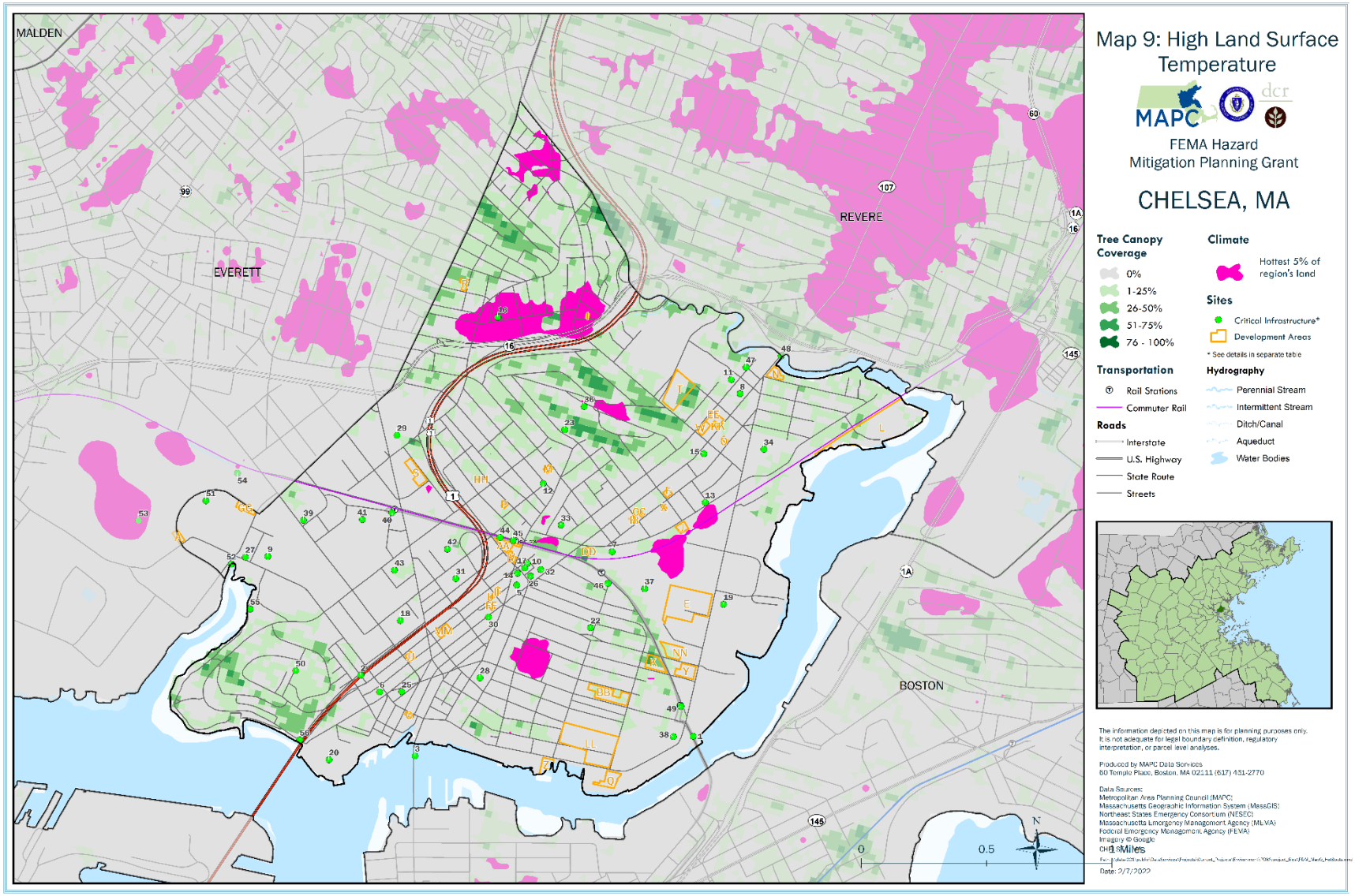
Produced by:
Metropolitan Area Planning Council
60 Temple Place, Boston, MA 02111 | (617) 933-0700

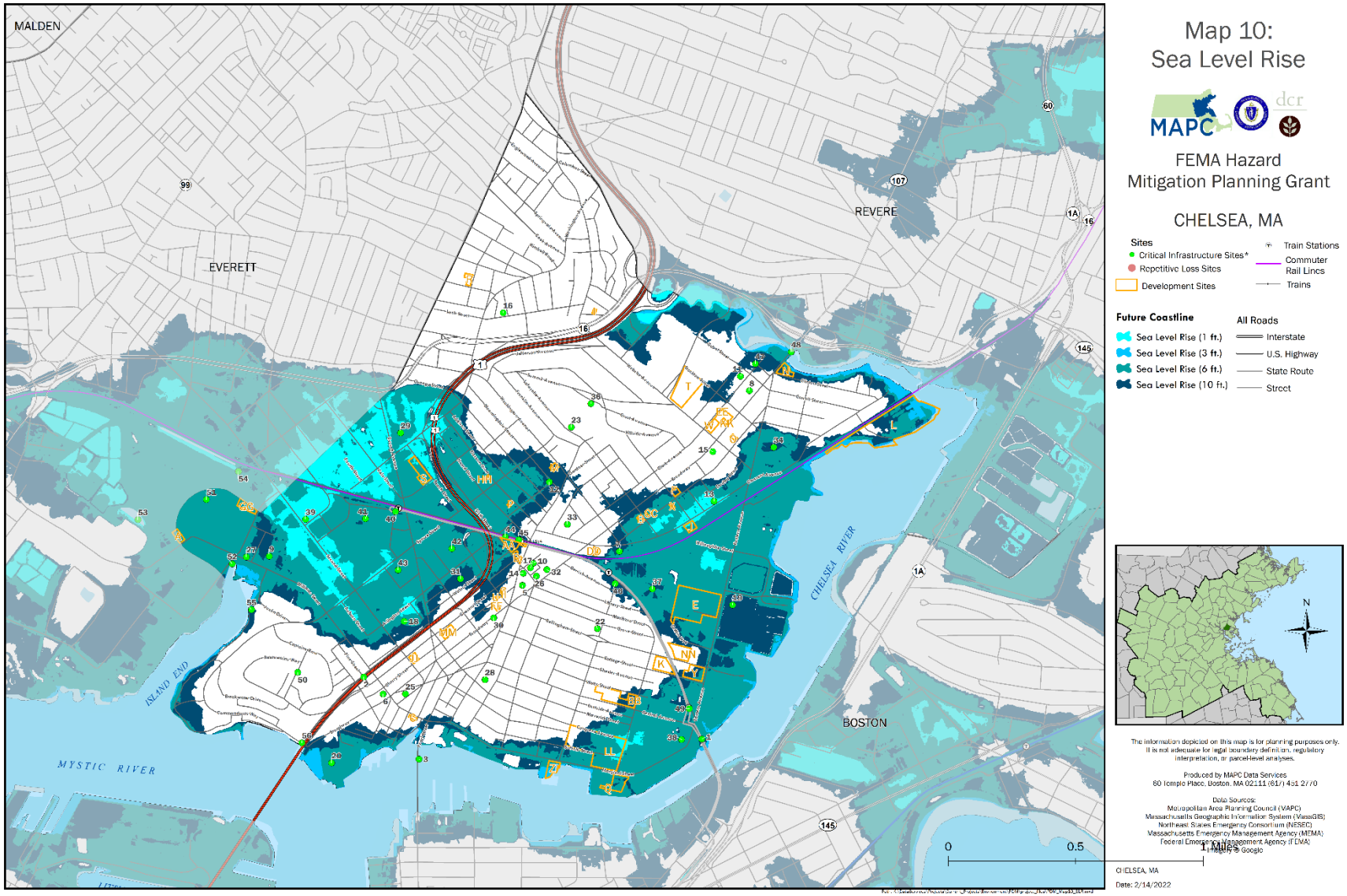
Data Sources:
Metropolitan Area Planning Council (MAPC)
Massachusetts Geographic Information System (MassGIS)
Massachusetts Department of Transportation (MassDOT)

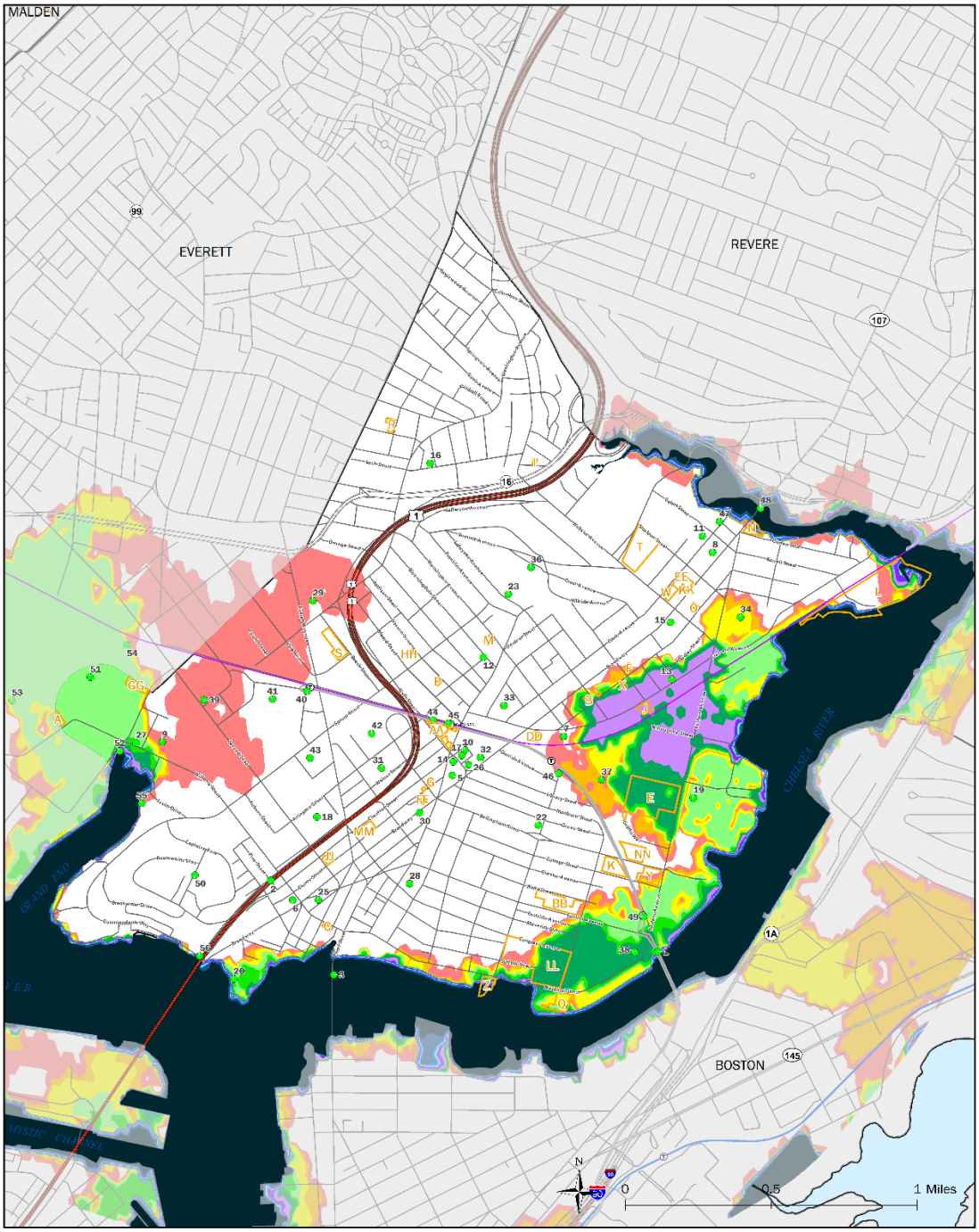
February 2022


Map 7: Composite Natural Hazards
MAPC
dcr
FEMA Hazard Mitigation Planning Grant
CHELSEA, MA
Sites
Critical Infrastructure
Repetitive Loss Sites
Development Areas
• See details in separate table
Composite Natural Hazards
Low (2 Hazards)
Moderate (3 Hazards)
High (4 Hazards)
Very High (5 Hazards)
Composite natural hazards shown for areas of existing development. Hazards include:
• 100 year wind speed of 110 MPH or higher
• Moderate landslide risk
• FEMA flood zones (100 year and 500 year)
• Average snowfall of 30.1" or more
• Hurricane surge inundation areas
Water Bodies
All Roads
Interstate
U.S. Highway
State Route
Street
Train Stations
Commuter Rail Lines
Trains
Subway Lines
Blue
Green
Orange
Red
Silver
EVERETT
REVERE
BOSTON
CHELSEA RIVER
ISLAND END
TIC RIVER
0
0.25
0.5 Miles
The information depicted on this map is for planning purposes only. It is not adequate for legal boundary definition, regulatory interpretation, or parcel level analyses.
Produced by MAPC Data Services
60 Temple Place, Boston, MA 02111 (617) 451-2770
Data Sources
Composite Natural Hazard:
Wind, Landslide Risk, Snow: Northeast States Emergency Consortium (NESEC)
Flood Zones - 2013 FEMA/MassGIS
Hurricane Surge - 2013 U.S. Army Corps of Engineers, New England District
Roads/Trains: MassDOT/ CTPS
Repetitive Loss Sites: DCR/Office of Flood Hazard Management
Critical Infrastructure: Metropolitan Area Planning Council (MAPC) /
CHELSEA, MA
Date: 2/7/2022


MALDEN
REVERE
EVERETT
BOSTON
0
0.5
1 Miles
Map 8:
Local Hazard Areas
MAPC
dcr
FEMA Hazard
Mitigation Planning Grant
CHELSEA, MA
Sites
Critical Infrastructure Sites*
Repetitive Loss Sites
* See details in separate table
Train Stations
Commuter Rail Lines
Trains
Locally Identificd Hazard Areas
Brush Fires
Flooding
Other
* See Section IV Risk Assessment
Development Sites
* See details in separate table
All Roads
Interstate
U.S. Highway
State Route
Street
N
The information depicted on this map is for planning purposes only. It is not adequate for legal boundary definition, regulatory interpretation, or parcel level analyses.
Produced by MAPC Data Services
60 Temple Place, Boston, MA 02111 (617) 451-2770
Data Sources:
Metropolitan Area Planning Council (MAPC)
Massachusetts Geographic Information System (MassGIS)
Northeast States Emergency Consortium (NESCO)
Massachusetts Emergency Management Agency (MEMA)
Federal Emergency Management Agency (FEMA)
Imagery © DigitalGlobe, 2015
CHELSEA, MA
Date: 2/14/2022


MALDEN
EVERETT
REVERE
BOSTON
Map 9: High Land Surface Temperature
MAPC
dcr
FEMA Hazard Mitigation Planning Grant
CHELSEA, MA
Tree Canopy Coverage
0%
1-25%
26-50%
51-75%
76 - 100%
Climate
Hottest 5% of region's land
Sites
Critical Infrastructure*
Development Areas
* See details in separate table
Transportation
Rail Stations
Commuter Rail
Roads
Interstate
U.S. Highway
State Route
Streets
Hydrography
Perennial Stream
Intermittent Stream
Ditch/Canal
Aqueduct
Water Bodies
The information depicted on this map is for planning purposes only. It is not adequate for legal boundary definition, regulatory interpretation, or parcel level analyses.
Produced by MAPC Data Services
60 Temple Place, Boston, MA 02111 (617) 451-2770
Data Sources:
Metropolitan Area Planning Council (MAPC)
Massachusetts Geographic Information System (MassGIS)
Northeast States Emergency Consortium (NESEC)
Massachusetts Emergency Management Agency (MEMA)
Federal Emergency Management Agency (FEMA)
Imagery © Google
CHELSEA
Miles
0
0.5
1
N
Date: 2/7/2022


MALDEN
EVERETT
REVERE
BOSTON
CHELSEA RIVER
ISLAND END
MYSTIC RIVER
Map 10:
Sea Level Rise
MAPC
dcr
FEMA Hazard
Mitigation Planning Grant
CHELSEA, MA
Sites
Critical Infrastructure Sites*
Repetitive Loss Sites
Development Sites
Train Stations
Commuter Rail Lines
Trains
Future Coastline
Sea Level Rise (1 ft.)
Sea Level Rise (3 ft.)
Sea Level Rise (6 ft.)
Sea Level Rise (10 ft.)
All Roads
Interstate
U.S. Highway
State Route
Street
N
The information depicted on this map is for planning purposes only. It is not adequate for legal boundary definition, regulatory interpretation, or parcel-level analyses.
Produced by MAPC Data Services
60 Temple Place, Boston, MA 02111 (617) 451-2770
Data Sources:
Metropolitan Area Planning Council (MAPC)
Massachusetts Geographic Information System (MassGIS)
Northeast States Emergency Consortium (NESEC)
Massachusetts Emergency Management Agency (MEMA)
Federal Emergency Management Agency (FEMA)
Imagery © Google
0
0.5
1 Miles
CHELSEA, MA
Date: 2/14/2022



Map 11: Coastal Flooding Annual Chance (Present)

MAPC dcr

FEMA Hazard Mitigation Planning Grant

CHELSEA, MA

Annual Chance of Coastal Flooding

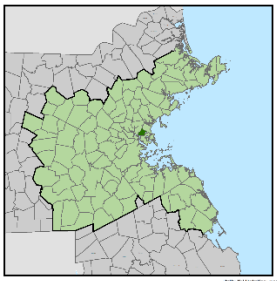
- Dry
- 0.1%
- 0.2%
- 0.5%
- 1%
- 2%
- 5%
- 10%
- 20%
- 25%
- 30%
- 50%
- 100%

Sites

- Critical Infrastructure Sites*
- Repetitive Loss Sites
- Development Sites
- Train Stations
- Commuter Rail Lines
- Trains

All Roads

- Interstate
- U.S. Highway
- State Route
- Street



The information depicted on this map is for planning purposes only. It is not adequate for legal boundary definition, regulatory interpretations, or parcel-level analyses.

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60 Temple Place, Boston, MA 02111 (617) 451-2770

Data Sources:
Metropolitan Area Planning Council (MAPC)
Massachusetts Geographic Information System (MassGIS)
Northeast States Emergency Consortium (NESEC)
Massachusetts Emergency Management Agency (MEMA)
Federal Emergency Management Agency (FEMA)
Imagery © Google
MA CHM: MassDOT, UMass Boston, Woods Hole Group (2021)

CHELSEA, MA

Date: 2/14/2022

APPENDIX B: HAZARD MITIGATION TEAM MEETINGS

Chelsea Hazard Mitigation Plan Update
Local Team Meeting #1

Tuesday, August 10, 2021
11:00 AM– 12:00 PM

Zoom Meeting
https://zoom.us/j/98442686720?pwd=Z295OzBkR0d6Z1p2bkZvMmQwKzJ2OT09

Meeting ID: 984 4268 6720
Passcode: 058462
One tap mobile
+13126266799,,98442686720#,,,,*058462# US (Chicago)
+16465588656,,98442686720#,,,,*058462# US (New York)

Dial by your location
+1 312 626 6799 US (Chicago)
+1 646 558 8656 US (New York)

AGENDA

1. **Welcome and Introductions**
2. **Overview of the HMP Project**
   - Overview of the FEMA Hazard Mitigation Plan
   - Planning process, tasks and schedule
3. **Local Data Updates from 2017 Plan**
   - Update Local Flooding Areas of Concern
   - Update Critical Facilities Inventory
   - During the meeting we will update maps using *Google MyMaps*
4. **Review Hazard Mitigation Goals from the 2017 Plan**

Next Steps:

5. **Review and Update of Existing Mitigation Measures**
6. **Public Meetings and Outreach**
   - Two Public Meetings, November and February
   - Identify local stakeholders to invite

APPENDIX B: HAZARD MITIGATION TEAM MEETINGS

Chelsea Hazard Mitigation Plan Update
Local Team Meeting #2

Thursday, October 21, 2021
12:30 – 2:00 PM

Zoom Meeting
https://zoom.us/j/95841840115

Meeting ID: 958 4184 0115
One tap mobile
+16468769923,,95841840115# US (New York)
+13017158592,,95841840115# US (Washington DC)

Dial by your location
+1 646 876 9923 US (New York)
+1 301 715 8592 US (Washington DC)

AGENDA

1. **Welcome and Introductions**

2. **Continue Local Data Updates from 2017 Plan**

   - Update Critical Facilities Inventory
   - Update Local Flooding Areas of Concern
   - We will map new sites online at the meeting with *Google MyMaps*

3. **Hazard Mitigation Goals for the 2021 Plan**

   - See the Mitigation Goals from the 2017 plan attached
   - Consider any updates/revisions; see suggested additional goals

4. **Review Status of Existing Mitigation Measures**

   - See summary of Existing Mitigation from 2017 plan attached
   - Note any changes or new measures adopted since 2017
   - Add notes on effectiveness, any changes or new measures needed

APPENDIX B: HAZARD MITIGATION TEAM MEETINGS

Chelsea Hazard Mitigation Plan Update
Local Team Meeting #3

Wednesday, January 12, 2022
10:00 – 11:30 AM

Zoom Meeting
Join Zoom Meeting
https://us06web.zoom.us/j/86169120568?pwd=T1NURWIwQXZTYk40R0tKNm15L0Nxdz09

Meeting ID: 861 6912 0568
Passcode: 735530
One tap mobile
+16465588656,,86169120568#,,,,*735530# US (New York)

AGENDA

1. Welcome and Introductions

2. Review and update status of Mitigation from the 2017 Plan

See attached Table 1. At the meeting we will fill in the 2 yellow columns:

- *Current status of mitigation recommendations:*
  1. Completed
  2. Partially completed
  3. Not completed
- *Retain mitigation in 2022 plan?*
  1. Yes, retain
  2. Yes, but with revisions
  3. No

3. Hazard Mitigation Goals Revised for the 2022 Plan

- See the revised Mitigation Goals attached
- Consider any further revisions and finalize for the plan

4. Preparing for the first Public Meeting, Jan. 25 Planning Board

- MAPC will give an overview presentation of the plan to the public
- We need *local contacts for stakeholders* to invite—email or mailing addresses
- Business groups, major employers, institutions, civic organizations, NGO's, etc.
- ***Please send contact information to mpillsbury@mapc.org by January 17***

APPENDIX B: HAZARD MITIGATION TEAM MEETINGS

Chelsea Hazard Mitigation Plan Update

Local Team Meeting #4

Monday, March 14, 2022

10:00 – 11:30 AM

Zoom Meeting

Join Zoom Meeting

https://us06web.zoom.us/j/84212866761

AGENDA

1. **Welcome and Introductions**

2. **Update Hazard Mitigation Recommendations for the 2022 Plan**

   - See attached **Draft Updated Hazard Mitigation Strategy**
   - Note mitigation measures to be **retained from the 2017 plan**
   - Add any **new mitigation measures** for the 2022 updated plan
   - For each mitigation measure, review and update if necessary:
     - time frame (2022-2027)
     - cost estimate (High, Medium, Low)
     - lead agencies
     - potential funding sources

3. **Next Steps**

   - Second public meeting, Planning Board, March 22: presentation of the draft plan, public comments
   - Finalize draft plan and submit to MEMA

4. **Adjourn**

APPENDIX C: PUBLIC MEETINGS

Chelsea Hazard Mitigation Plan

Public Meeting
Hosted by the Planning Board

Natural hazards can have serious impacts on the City of Chelsea and its residents and businesses



The City of Chelsea is preparing an updated Hazard Mitigation Plan to help the City reduce its vulnerability to natural hazards such as flooding, hurricanes, and winter storms. Please join the City for a presentation about the Hazard Mitigation Plan at a public meeting hosted by the Planning Board. Questions and suggestions for the plan are welcome.

Tuesday, February 22, 2022
6:00 pm

The meeting will be held remotely by video conference.
Please join the meeting from your computer, tablet or smartphone.
To request a link to log on to the meeting please send an email to
jdepriest@chelseama.gov

City of Chelsea Massachusetts

APPENDIX C: PUBLIC MEETINGS

Plan de Mitigación de Riesgos de Chelsea

Reunión Pública

Organizado por la Junta de Planificación

Desastres naturales pueden impactar gravemente en la Ciudad, sus residentes y negocios

La Ciudad de Chelsea está preparando una actualización del Plan de Mitigación de Riesgos para ayudar a la Ciudad a reducir su vulnerabilidad a los peligros naturales como inundaciones, huracanes y tormentas de invierno.

Participe de una presentación sobre el Plan de Mitigación de Riesgos en una reunión pública organizada por la Junta de Planificación. Las preguntas y sugerencias para el plan son bienvenidas.

Martes 22 de febrero de 2022
6:00 pm

La reunión se realizará por videoconferencia.
Participe de la reunión desde su computadora, tablet o teléfono.
Para solicitar un link para iniciar sesión en la reunión, envíe un correo electrónico a jdepriest@chelseama.gov

City of Chelsea Massachusetts

APPENDIX C: PUBLIC MEETINGS

Amanda Linehan, Communications Manager, Metropolitan Area Planning Council
617-933-0705, alinehan@mapc.org

CALENDAR LISTING / MEDIA ADVISORY

CHELSEA'S FEMA HAZARD MITIGATION PLAN TO BE DISCUSSED AT FEBRUARY 22 PUBLIC MEETING

Who: Chelsea residents, business owners, institutions, and non-profit organizations, and others who are interested in preventing and reducing damage from natural hazards.

What: At a public meeting on Tuesday, February 22 at 6:00 PM, a presentation on the *Chelsea Draft Hazard Mitigation Plan, 2022 Update* will be hosted by the Chelsea Planning Board. The presentation will be given by the Metropolitan Area Planning Council, which is assisting the City in the preparation of the plan. There will be an opportunity for questions and discussion following the presentation.

The City of Chelsea is preparing the updated 2022 Hazard Mitigation Plan to document natural hazards that affect the City, such as floods, hurricanes, and severe winter storms, and to recommend actions that the City can take to reduce its vulnerability to these hazards.

Once completed and approved by the Federal Emergency Management Agency (FEMA), the City will be eligible for grants from FEMA that support significant mitigation projects such as drainage improvements.

When: **Tuesday, February 22, 2022, 6:00 PM**

Where: **Virtual meeting online**
The meeting will be held remotely by video conference.
Please join the meeting from your computer, tablet or smartphone.
To request a link to log on to the meeting please send an email to jdepriest@chelseama.gov

MAPC is the regional planning agency for 101 communities in the metropolitan Boston area, promoting smart growth and regional collaboration. More information about MAPC is available at www.mapc.org.

##

APPENDIX C: PUBLIC MEETINGS

CITY OF CHELSEA, MA
Planning Board

City Hall, 500 Broadway, Room 106 · Chelsea, MA 02150
Phone: 617.466-4180 · Fax: 617.466-4195
https://www.chelseama.gov/planning-board

CHELSEA PLANNING BOARD

Notice is hereby given in accordance with the General Laws of the Commonwealth of Massachusetts and the Massachusetts Zoning Act that a meeting of the Chelsea Planning Board will be held via video conference on:

Tuesday, March 22, 2022, 6:00 PM

I. **Call to Order**

II. **Approval of Minutes from February 22, 2021**

III. **Public Meeting/Hearing Petitions***

2022-02 361 Broadway – Arx BC LLC – PUBLIC HEARING
For Major Site Plan Review and a recommendation to the ZBA on the Special Permits and Variances for the demolition of a garage parking structure and the construction of an addition and the conversion of an existing residential structure and commercial structure from 19 residential units to 62 residential units

IV. **Other Business**

1. Hazard Mitigation Plan Update – Presentation & Discussion

V. **Adjournment**

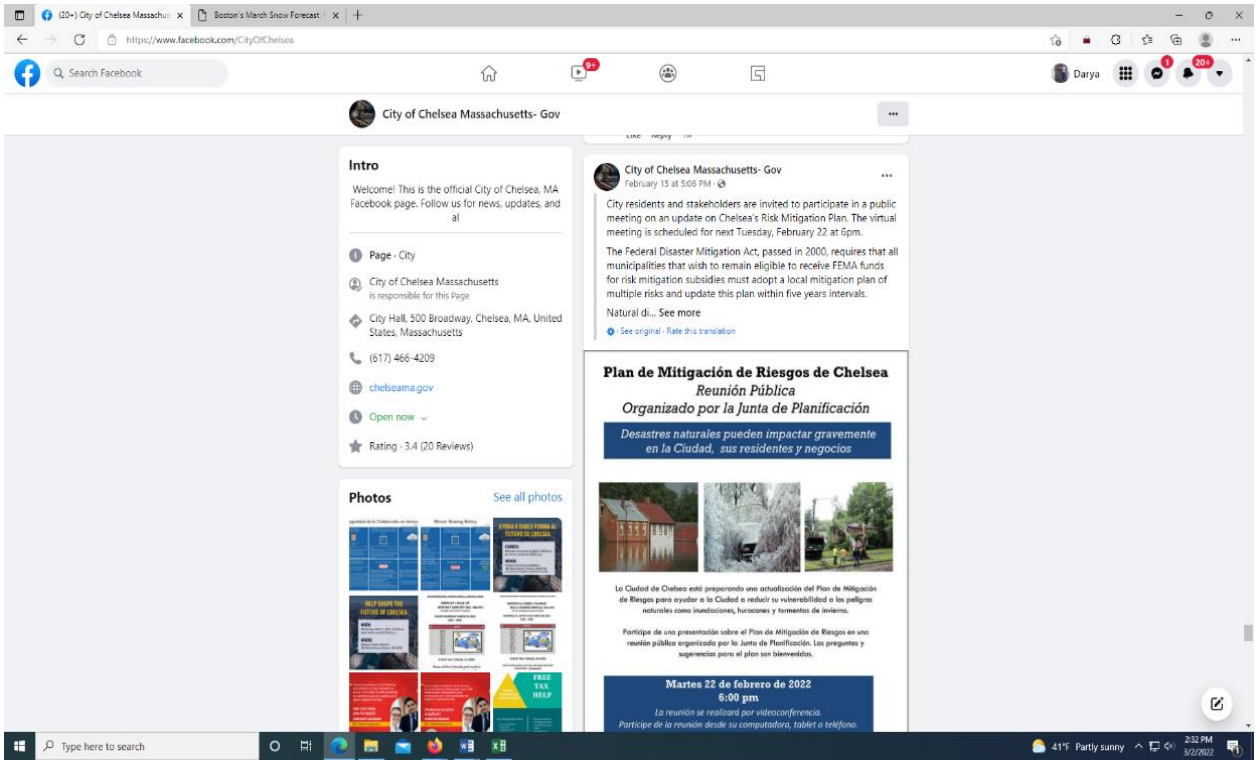
All interested parties wishing to provide a public comment or to join the meeting must communicate with jdepriest@chelseama.gov. Name and address must be included in order to be read during the Public Speaking section of the meeting and email address in order to join the meeting. Plans and copies of filings may be viewed at the Office of the City Clerk.

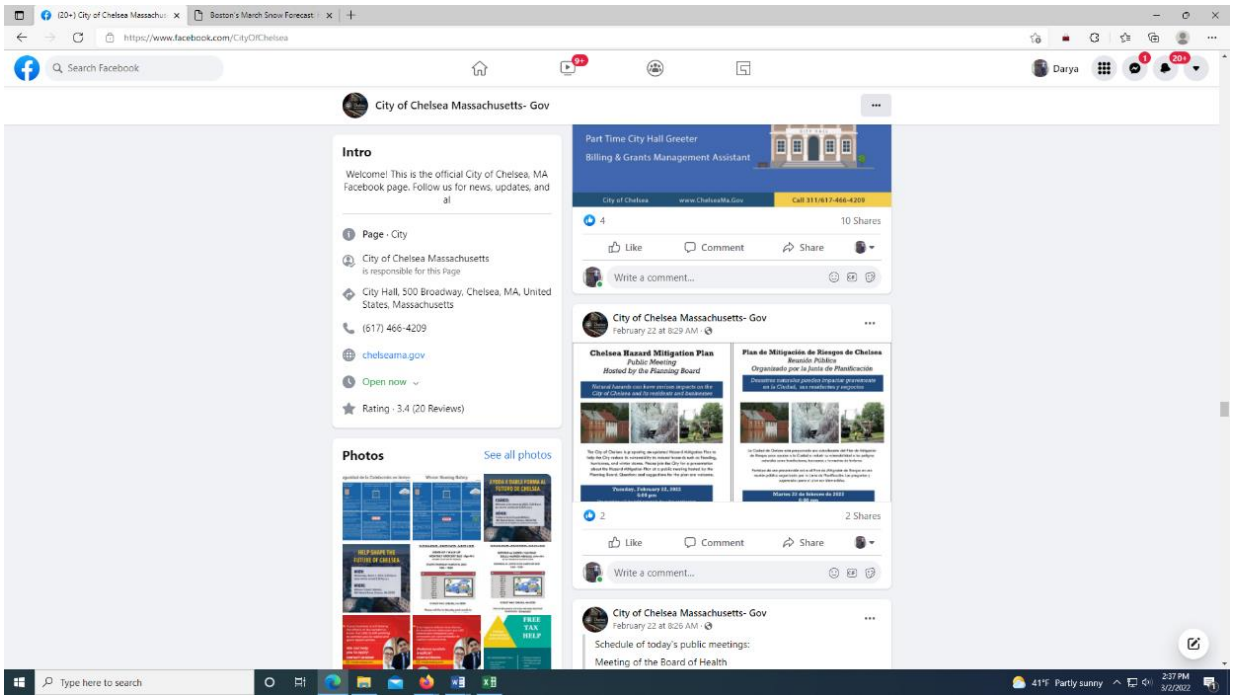
***Order of Hearings at discretion of Board**

APPENDIX C: PUBLIC MEETINGS

Here is some documentation of the outreach we did.

- An email I sent to community partner organizations is below. They were encouraged to share this information with their members/constituents, though we didn't track if they did. This went out to:
    - La Colaborativa/The Chelsea Collaborative
    - GreenRoots
    - CAPIC
    - The Neighborhood Developers
    - Beth Israel/Leahy Health Community Initiatives
    - Chelsea Community Connections
    - MGH/Partners Health Care
    - Chelsea Housing Trust Fund board
    - Chelsea Housing Authority
- Below are two screenshots of information about the meeting that was posted on the City's official Facebook page on 2/15 and 2/22.
- And the flyers (Spanish and English) are attached.





---------- Forwarded message ---------
From: **Mattes, Darya** <dmattes@chelseama.gov>
Date: Thu, Feb 17, 2022 at 9:10 AM
Subject: Chelsea hazard mitigation plan update public meeting: next Tuesday

Hello community partners,

Chelsea is updating its hazard mitigation plan this year -- this plan is what's submitted to FEMA every five years to identify local threats from natural hazards (such as storms, heat, cold, etc.). It also specifies priority actions to address these hazards to help protect people, buildings, and infrastructure in Chelsea. Communities with an up-to-date plan on file are eligible for FEMA grant funding and are better prepared to address their vulnerabilities to natural hazards.

As part of this process, there will be a presentation about the hazard mitigation planning process, and Chelsea's plan in particular, at next week's Planning Board meeting, Tuesday, 2/22 at 6pm (the presentation is part of a regular monthly meeting, and will begin at least 30 minutes into the meeting, though it's hard to specify an exact time). If you, or anyone from your organization, is interested in attending, we'd love to have you there. It is very valuable to hear community questions and input as the plan is being updated. There is more information in the attached flyer (in English and Spanish).

If you're not able to attend on Tuesday, there will be two additional opportunities to engage with this process: a draft plan to review and a second meeting in April, which will focus more on the finalized plan. We hope your organization can engage with the process in one of these ways, and feel free to share this information and pass the attached fliers along to colleagues, members, and anyone else you think might be interested.

APPENDIX C: PUBLIC MEETINGS

Chelsea Hazard Mitigation Plan

Public Meeting
Hosted by the Planning Board

Natural hazards can have serious impacts. Join us for a presentation on Chelsea's Hazard Mitigation Plan



The City of Chelsea has prepared an updated Hazard Mitigation Plan to help reduce its vulnerability to natural hazards such as flooding, hurricanes, and winter storms. Please join the City for a presentation of the draft Hazard Mitigation Plan at a public meeting hosted by the Planning Board. Questions and comments on the draft plan are welcome.

Tuesday, March 22, 2022
6:00 pm

The meeting will be held remotely by video conference.
Please join the meeting from your computer, tablet or smartphone.
To request a link to log on to the meeting please send an email to
jdepriest@chelseama.gov

City of Chelsea Massachusetts

APPENDIX C: PUBLIC MEETINGS

Amanda Linehan, Communications Manager, Metropolitan Area Planning Council
617-933-0705, alinehan@mapc.org

CALENDAR LISTING / MEDIA ADVISORY

CHELSEA'S FEMA HAZARD MITIGATION PLAN TO BE PRESENTED AT MARCH 22 PUBLIC MEETING

Who: Chelsea residents, business owners, institutions, and non-profit organizations, and others who are interested in preventing and reducing damage from natural hazards.

What: At a public meeting on Tuesday, March 22 at 6:00 PM, a presentation of the *Chelsea Draft Hazard Mitigation Plan, 2022 Update* will be hosted by the Chelsea Planning Board. The presentation will be given by the Metropolitan Area Planning Council, which assisted the City in the preparation of the draft plan. There will be an opportunity for questions and discussion following the presentation, and the draft plan will be available for review and comments.

The City of Chelsea has prepared an updated 2022 Hazard Mitigation Plan to address natural hazards such as floods, hurricanes, and severe winter storms, and to recommend actions that the City can take to reduce its vulnerability to these hazards. The 2022 draft plan will replace the City's current Hazard Mitigation Plan, which was approved in 2017, and must be updated every five years.

Once the updated plan is approved by the Federal Emergency Management Agency (FEMA), the City will be eligible for grants from FEMA that support significant mitigation projects such as drainage improvements.

When: **Tuesday, February 22, 2022, 6:00 PM**

Where: **Virtual meeting online**
The meeting will be held remotely by video conference.
Please join the meeting from your computer, tablet or smartphone.
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##

APPENDIX C: PUBLIC MEETINGS

Public Notice to the Cities of Boston, Everett, and Revere

PUBLIC MEETING NOTICE

CITY OF CHELSEA
PRESENTATION ON THE CHELSEA DRAFT HAZARD MITIGATION PLAN
HOSTED BY THE CHELSEA PLANNING BOARD

The City of Chelsea has prepared its draft *Hazard Mitigation Plan 2022 Update* to reduce the City's vulnerability to natural hazards such as flooding, hurricanes, and winter storms.

As part of the planning process, all neighboring communities to Chelsea, including Boston, Everett, and Revere, are being notified of a public presentation on the draft plan to be hosted by the Chelsea Planning Board as follows:

Chelsea Planning Board
Tuesday, March 22, 2022 at 6:00 PM
The meeting will be held remotely by video conference.
Please join the meeting from your computer, tablet or smartphone.
To request a link to log on to the meeting please send an email to
jdepriest@chelseama.gov

If you have any questions about this, please feel free to contact:

Martin Pillsbury
Director of Environmental Planning,
Metropolitan Area Planning Council
mpillsbury@mapc.org

APPENDIX C: PUBLIC MEETINGS

CITY OF CHELSEA, MA
Planning Board

City Hall, 500 Broadway, Room 106 · Chelsea, MA 02150
Phone: 617.466-4180 · Fax: 617.466-4195
https://www.chelseama.gov/planning-board

CHELSEA PLANNING BOARD

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All interested parties wishing to provide a public comment or to join the meeting must communicate with jdepriest@chelseama.gov. Name and address must be included in order to be read during the Public Speaking section of the meeting and email address in order to join the meeting. Plans and copies of filings may be viewed at the Office of the City Clerk.

***Order of Hearings at discretion of Board**

APPENDIX D: PLAN ADOPTION BY THE CITY

< PRINT ON CITY LETTERHEAD >

CERTIFICATE OF ADOPTION
CITY OF CHELSEA, MASSACHUSETTS

A RESOLUTION ADOPTING THE
CITY OF CHELSEA HAZARD MITIGATION PLAN 2022 Update

WHEREAS the City of Chelsea established a Committee to prepare the *City of Chelsea Hazard Mitigation Plan 2022 Update*; and

WHEREAS the *City of Chelsea Hazard Mitigation Plan 2022 Update* contains several potential future projects to mitigate potential impacts from natural hazards in the City of Chelsea, and

WHEREAS duly noticed public meetings were held by the Chelsea Planning Board on February 22, 2022, and on March 22, 2022, and

WHEREAS the City of Chelsea authorizes responsible departments and/or agencies to execute their responsibilities demonstrated in the plan,

NOW, THEREFORE BE IT RESOLVED that the Chelsea City Council adopts the *City of Chelsea Hazard Mitigation Plan 2022 Update*, in accordance with M.G.L. 40 §4 or the charter and ordinances of the City of Chelsea.

ADOPTED AND SIGNED this Date _____

_____
Signature

_____
Name and Title